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**Disease-Bearing Mosquitoes
of North and Central America, the
West Indies, and the Philip-
pine Islands**

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PREFACE.

In the Sundry Civil Act for 1913, under the appropriation for printing and binding for the War Department, it was provided:

That the sum of \$3,000, or so much thereof as may be necessary, may be used for the publication from time to time of bulletins prepared under the direction of the Surgeon General of the Army, for the instruction of medical officers, when approved by the Secretary of War.

Similar provision was made in the Sundry Civil Act for 1914, and it is hoped that this appropriation will be continued from year to year in the future. It is intended that these bulletins shall be used for the publication to the Medical Corps of the special technical work of the service laboratories, the reports of the Boards for the Study of Tropical Diseases, and other work of medical officers which is of too special or technical a character to make it acceptable for publication in the medical journals and the Military Surgeon.

The bulletin will be published, if possible, at least quarterly. Officers of the corps are requested to submit suitable articles to this office for use in the bulletin, with the understanding that they may be published elsewhere by the author if found not suitable for the bulletin.

GEO. H. TORNEY,
Surgeon General, United States Army.

SEPTEMBER 24, 1913.

ORDER.

A board of officers of the Medical Corps, representing the Sanitary and Statistical Division and the Library of the Surgeon General's Office and the Laboratory of the Army Medical School, is hereby convened for the purpose of collecting materials and arranging for the publication of the bulletins for the instruction of medical officers authorized by the act approved June 23, 1913.

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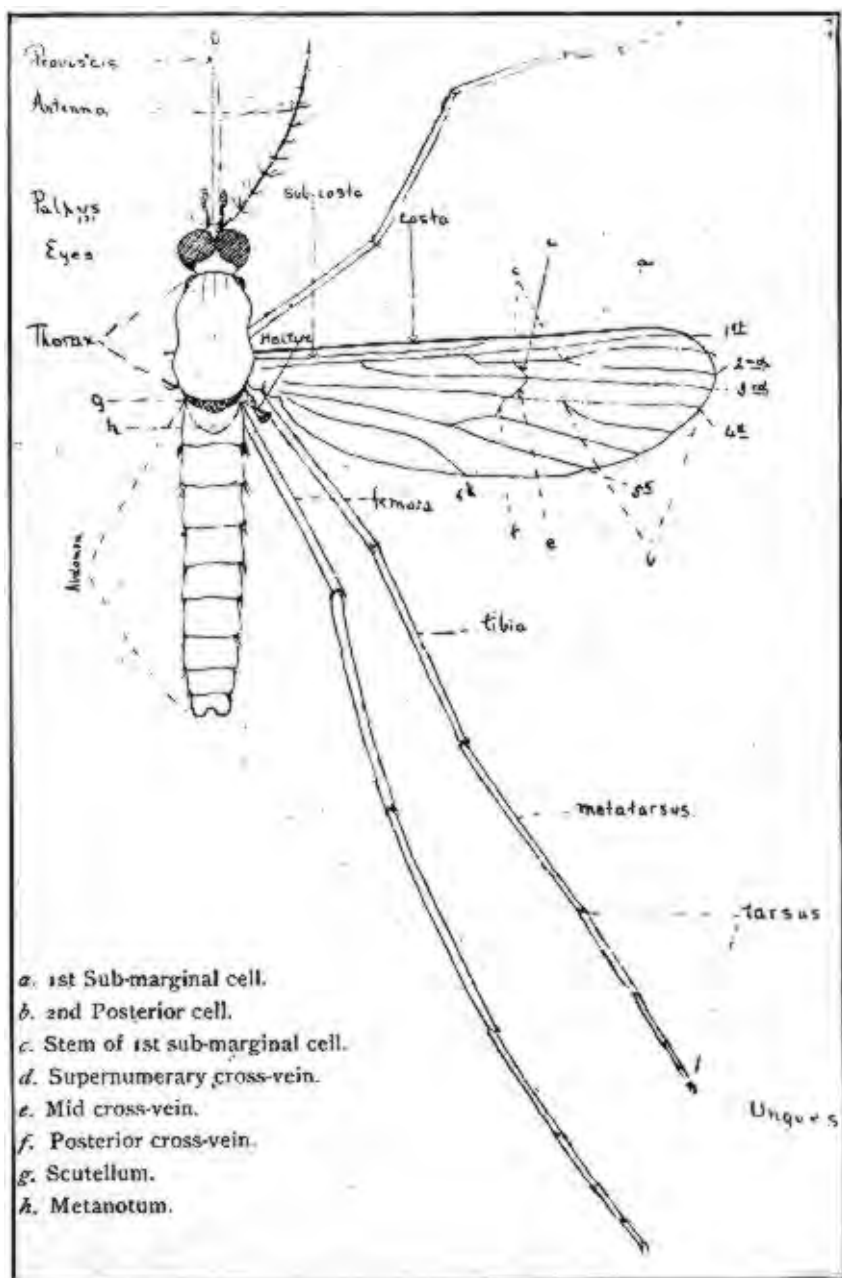


DIAGRAM OF MOSQUITO SHOWING PARTS.

NOTE.—The part of the leg marked “metatarsus” is in reality the first tarsal joint; both terms are used.

PRELIMINARY.

To take up the study of mosquitoes intelligently it is necessary to know a little of their position among insects.

Entomologists in considering the subject divide from the nearly related *Arthropoda*, the *Hexopoda* (true insects), and these are again divided into various orders, of which *Hemiptera*, *Lepidoptera*, *Diptera*, *Coleoptera*, etc., are perhaps the better known among the laity. Of these our present study takes us to the

ORDER DIPTERA (true flies).

"The members of this order have only two wings; these are borne on the mesothorax. The metathorax is furnished with a pair of knobbed threads, the halteres. The mouth parts are formed for sucking. The metamorphosis is complete."¹

The *Diptera* are divided into two suborders, *Orthorrhapha* and *Cyclorrhapha*, of which we have to do with the former.

The *Orthorrhapha* are again divided into "long horned" = *Nematocera*, and "short horned" = *Brachycera*; the *Nematocera* into "True Nematocera," and "anomalous Nematocera." Among the former, as aquatic nematocerous insects we find the mosquitoes, i. e.

Family CULICIDÆ.

To follow through the classification from Order *Diptera* to Family *Culicidæ*, even if we omit the forms in which we are not interested, is not necessary for the work we have in hand, and the whole may be found in any first-class manual on entomology.

Looking at the *Culicidæ*, i. e., taking a mosquito and examining it with a hand glass, we find it following the definition of the order and suborder; two wings, on mesothorax; halteres on metathorax; mouth formed for sucking; jointed, pendulous, palpi; antennæ usually long, and frequently having whorls of long hairs, especially in the male; legs long and slender; abdomen usually long and slender, while the family characteristics are: wings slender, veins bearing small "scales," and the apical and dorsal margins fringed. The immature forms are aquatic wholly, as are also those of many nearly related forms.

The accompanying plate will bring out some of these points, and others to be referred to later. (Pl. I.)

The one distinctive feature which divides the culicidæ (including *Corethrinæ*) from all other flies is the wing venation.

These distinctions are more easily shown by figure than by words, and the wings of several flies, often mistaken for mosquitoes, given on the following pages will indicate these differences.

In comparing these wings we find the cephalad marginal vein (costa) running to the apex and joined by the subcosta somewhere exterior to the middle of the wing. In the mosquito the first long

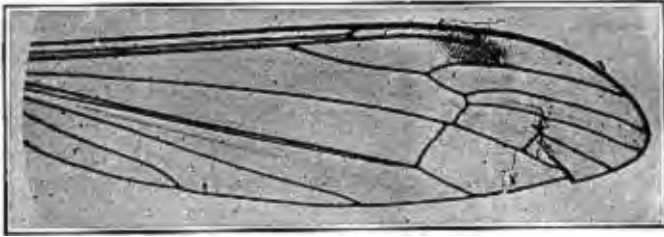


FIG. 1. *Tanapus*.

vein (radius) extends from the root of the wing to the apex, the second rising from the first and forked toward its distal end; the third rises at an angle from the second (or, as it is often expressed, from the cross veins); the fourth from the root and is also forked toward the

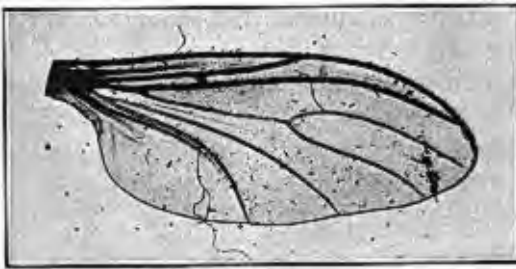


FIG. 2. Fam. *Mycetophilidae Sciara*.

distal end; the fifth from the root and forked near the middle of its length; the sixth from the root.

In some genera the base of the third is continued to the root as an incassation, and in one genus the anal fold is developed into a seventh vein and clothed with

scales. The comparative length and width of the first submarginal and second posterior cells, i. e., the cells included in the branches of the second and fourth long veins, and the position of the cross veins, though more or less variable, are of value in determining genera and species.

The wing having decided by its venation the family of the insect, the next step is to discover its sex, and this may be done either by a study of the genitalia, which usually necessitates the destruction of the specimen, or, more readily in the *Culicidæ* and some of



FIG. 3. *Rhyphus*.

the nearly related flies by the antennæ, which are, with very few exceptions, markedly different, those of the male being plumose, of the female pilose, as may be seen by the photographs, figure 6 and figure 7, which latter unfortunately shows the female as a heavy cablelike,

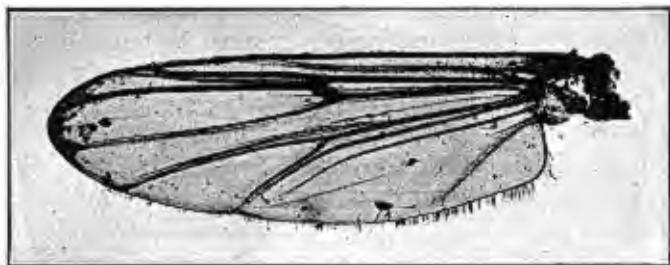


FIG. 4. *Chironomus*.

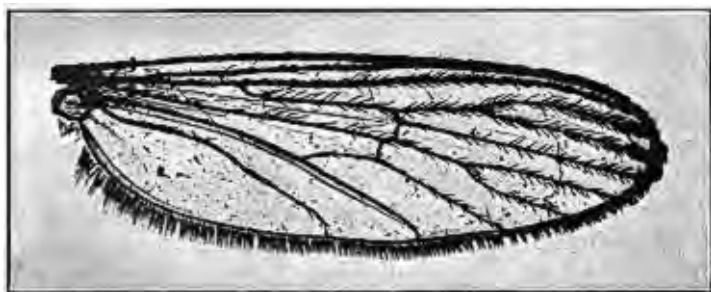


FIG. 5. *Culex* (Mosquito).



FIG. 6. Male antennae (*anophelinae*.)



FIG. 7. Female antennae
(*anophelinae*.)

as found in some of the Anophelines, instead of a thin threadlike organ as shown in plate 1.

In all cases the determination of sex must be made before further steps are taken, as the long palpi found in the male in many genera will lead to much confusion if the sex be not recognized.

Illustrative of this confusion is the fact that the male *Stegomyia* has palpi greatly resembling the female *Anophelinæ*, and if no regard is paid to the antennæ serious error is unavoidable.

CLASSIFICATION.

The division of the *Culicidæ* into subfamilies, genera, and species has been and still is a subject of discussion, each authority having some preference to which his fellow-workers do not accede. There are, of course, many arguments as to the basis on which the classification should be made, but it must always be remembered that every classification is to some extent arbitrary and artificial, and that probably every basis for division has some value, and none are absolutely without objection. The old division on palpal lengths is severely criticised by some, although retained by equally good authorities; the division on scale characters shares the same fate, although Edwards says "it is true that groups of species frequently show the same type of ornamentation in all their members," and it must therefore have some value as a basis for such division; the unguis and genitalia have also been used as bases for division, the latter being held of much value at the present time. Any classification based only on the male organs without corresponding known differences in the female must be of necessity of questionable value, but lately it has been shown that the method of egg laying and the position of the eighth abdominal segment in the female, whether it be slender and retractile or broad, truncate, and not retractile, runs parallel to a large extent both to unguis differences and to differences in the male genitalia, and this fact puts the genital differences on a usable basis.

It seems probable that the future classification of mosquitoes, at least so far as the first general groupings are concerned, will depend largely on this basis, but it is also likely that in the necessity for breaking these large groups into smaller ones the other bases for classification will be found to be much too valuable to be entirely discarded.

Illustrations of palpi, of cephalic scales, and of the terminal abdominal segments in the female are given below, but the subject of male genitalia is too intricate to be discussed here, and for various reasons the nomenclature used by Mr. Theobald is retained and his table for general classification is appended.

The divisions are, as will be seen by the following, based partly on differences of mouth parts, partly on scale shapes and position, and partly on other bodily characteristics.

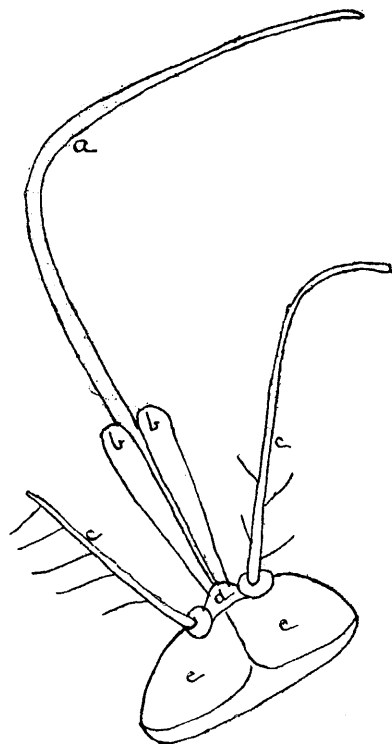


Fig. 8.—♀ *megarrhinina*.
 a Proboscis.
 bb Palpi.
 cc Antennae much broken.

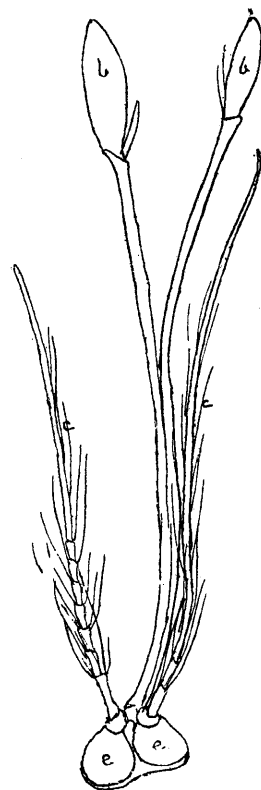


Fig. 9.—♂ *anophelina*.
 Proboscis hidden.
 bb Clubbed palpi.
 cc Antennae (have been wet).
 ee Eyes.

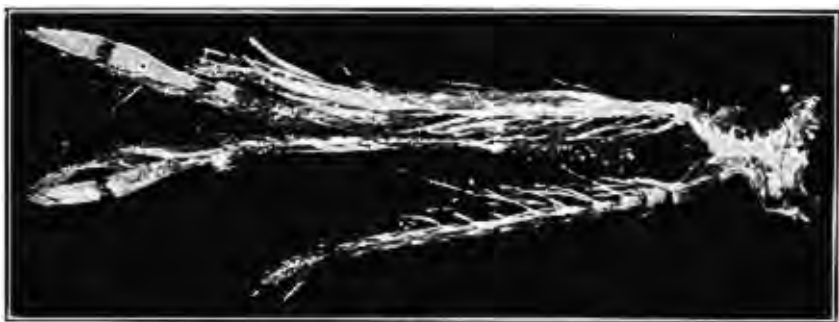


Fig. 9.—♂ head (*anopheline*).



Fig. 8.—♀ head (*megarrhinine*).

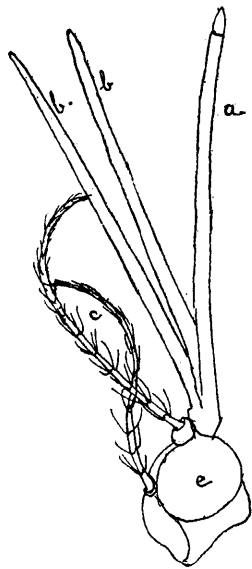


Fig. 10.—♀ *anophelinæ*.
 a Straight proboscis.
 bb Long palpi.
 c Antennæ.
 e Eyes.



Fig. 11.—♂ *stegomyia*.
 a Proboscis.
 bb Long thin palpi.
 cc Antennæ.
 ee Eyes.



Fig. 11.—♂ head (*stegomyia*).



Fig. 10.—♀ head (*anophelinae*).

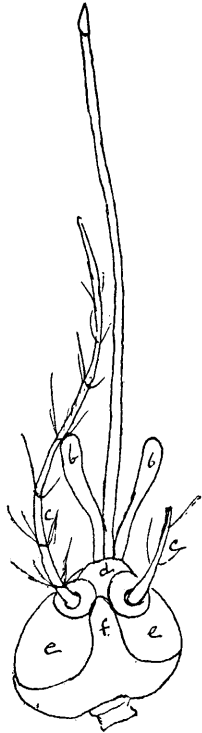


Fig. 12.—♀ *culicinx*.
 a Straight proboscis.
 bb Short palpi.
 cc Antennæ.
 d Clypeus.
 ee Eyes.
 f Vertex.

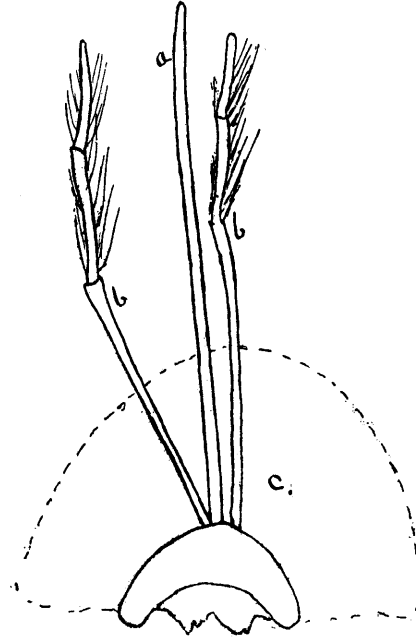


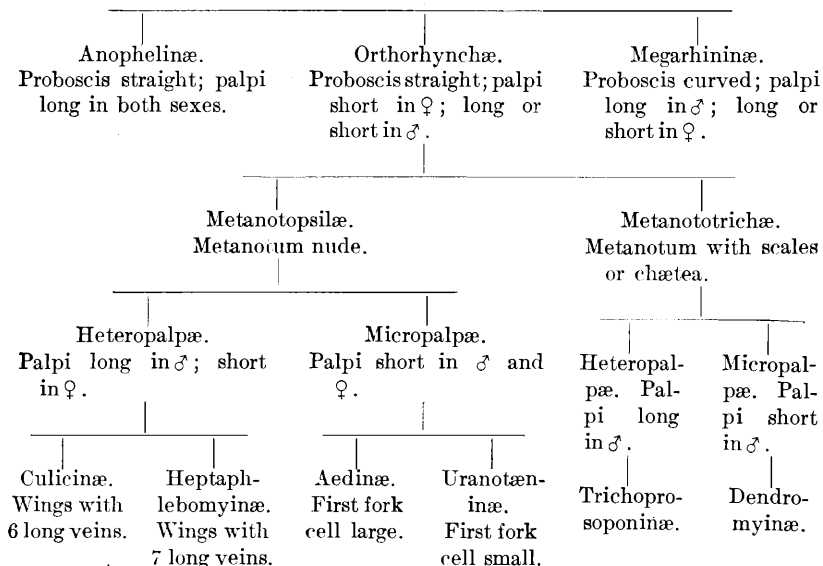
Fig. 13.—♂ *culicinx*.
 a Straight proboscis.
 bb Plumed palpi of many male *culicinx*.
 c ♂ Antennæ poor behind.



Fig. 12.—♀ head (*culicine*).



Fig. 13.—♂ head (*culicine*).

CULICIDÆ.¹TABLE OF SUBFAMILIES.²

- A. Scutellum simple, never trilobed. Proboscis straight; palpi long in ♂ and ♀ Anophelinæ.
- AA. Scutellum trilobed.
- a. Proboscis strongly recurved; first submarginal cell very small Megarhininæ.
- aa. Proboscis straight; metanotum nude.
- β. Wings with six long scaled veins.
- γ. Antennæ with second joint normal in length.
- δ. First submarginal cell as long or longer than second post cell.
- E. Palpi of ♀ shorter than proboscis, of ♂ long Culicinæ.
- εε. Palpi short in ♂ and ♀ Aedinæ.
- δδ. First submarginal cell very small, smaller than second post cell Uranotæninæ.
- γγ. Second segment of antennæ very long Deinoceratinæ.
- ββ. Wings with 7 long scaled veins Heptaplelebomyinæ.
- aaa. Proboscis straight; metanotum with scales or chaetæ.
- δ. Palpi long in ♂, short in ♀ Trichoprosoponinæ.
- δδ. Palpi short in ♂ and ♀ Dendromyminæ.
- aaaa. Proboscis elbowed Limatinæ.

This list of subfamilies leaves out of consideration the *Corethrinæ*, the wing venation of which is identical with the other *Culicidæ*,

¹ Mon. Cul. of the World, Theob., Vol. IV, pg. 17.

² Theobald, F. V., Monograph Cul. of the World. Vol. IV, pg. 18.



FIG. 14. Curved scales on head of *culicinae*



FIG. 15. Forked scales on occiput of *culicinae*.



FIG. 16. Head *Stegomyia fasciata* Fabr. showing flat scales.

but the mouth parts are not formed for piercing, and the scales of the body and wings are hairlike.

I prefer to consider this a part of the family *Culicidæ*, but as its lack of piercing mouth parts makes it of no value to the pathologist its further consideration is omitted.

The scale differences are not always easy to follow, but the curved scales found on the vertex and occiput of *culices*, the forked scales found in some *anophelinæ*, and many *culicina* are well illustrated by the preceding photographs:

The flat scales on the sides are indicated merely by a blur in the first photograph.

The flat head scales of *Stegomyia*, *Desvoidya*, etc., are distinctive when seen, although the photograph merely gives a smooth effect and does not indicate clearly the closely imbricated flat scales which cover the head.

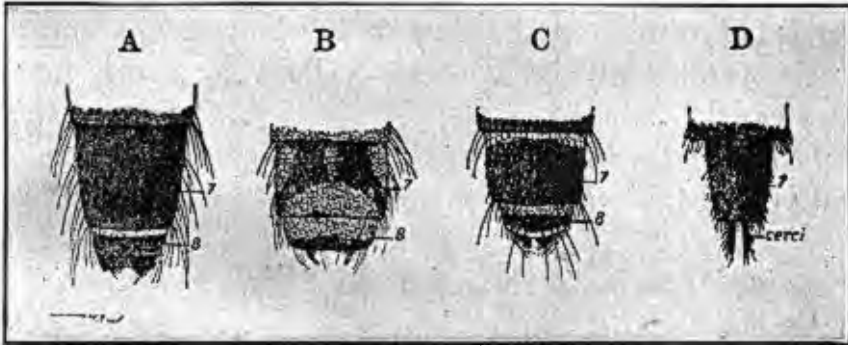


FIG. 17. After Edwards.

FIG. 17.—Terminal segments of female abdomen (dorsal view).

A. *Culex tigripes* v. *fuscus*, distended abdomen.

B. *Culex tigripes*, abdomen not distended.

C. Abdomen broad, not retractile.

D. Abdomen narrow, usually retractile.

No illustrations of male genitalia are given, because to be able to use them understandingly it is necessary to have acquired considerable information as to the differences and as to what differences are significant.

In the group (C) with broad, nonretractile abdomen the eggs are laid in rafts and the claws of the female are *never* toothed.¹

In the group (D), having the abdomen slender and usually retractile, the eggs are laid singly and the claws on the fore and mid legs of the female are nearly always toothed.

¹ Edwards, F. W., Synopsis of the Species of African Culicidæ other than Anopheles. Bull. Ento. Res., Vol. III, P. I, pg. 1.

These differences have reference to the general subfamily of *Culicinæ*, and do not apply to the *Anophelinæ*.¹

When mosquitoes were shown to be connected with the transmission of disease the interest in them became much increased, and new forms were found and described in such numbers that from being quite insignificant the family has become a large one. At the time of this sudden increase in interest the old classification seemed inadequate and many new classifications, new subfamilies, genera, and species were created, and because of the number of classifications the subject became much clouded.

Of the various subfamilies then created, only the subfamily *Anophelinæ* (or tribe *Anophelini*) and the subfamily *Culicinæ* (or tribe *Culicini*) contain the forms connected with the transmission of disease,¹ and to their consideration this paper will be limited.

¹ Daniels is inclined to suspect the *Aedinæ* (palpi short in both sexes) as being possible disseminators of malaria in jungles, but there is no complete proof of this.

ANOPHELINÆ Theob.

Characters.—The scutellum is simple, never trilobed, the palpi are long in the male and female, and the larvæ have no respiratory siphon.

Mr. Theobald created this subfamily and divided it into several genera based mostly on scale differences. The distinctions are not easily obvious to the untrained eye, and there is a probability that some of these genera will be merged into others or even all of them submerged under the old *Anopheles*, but as the process of reclassifying mosquitoes is still in the crucible of development and much clouded by contention I have retained, as far as may be, Mr. Theobald's nomenclature, for it is much easier to regroup these genera into one genus than it is to find differences that may separate the parts of a large group.

The species considered will be those connected with, or probably connected with, the transmission of disease, and a few which are frequently mistaken for them. The only exception to this is in the case of the Philippine *Anophelinæ*, where many new forms have been discovered with which no experimental work has been done, and their relation to the transmission of disease is not proven.

Genus, ANOPHELES Meigen (as restricted by Theobald).

Thorax and abdomen with hairlike curved scales (practically hairs); palpi in the female thin, not densely scaled; wings with veins covered with lanceolate scales, which may or may not form spots; the head never has flat lateral scales. The majority are large species.

Only one species has been reported from the Philippines.

ANOPHELES FORMOSUS Ludlow (1909).

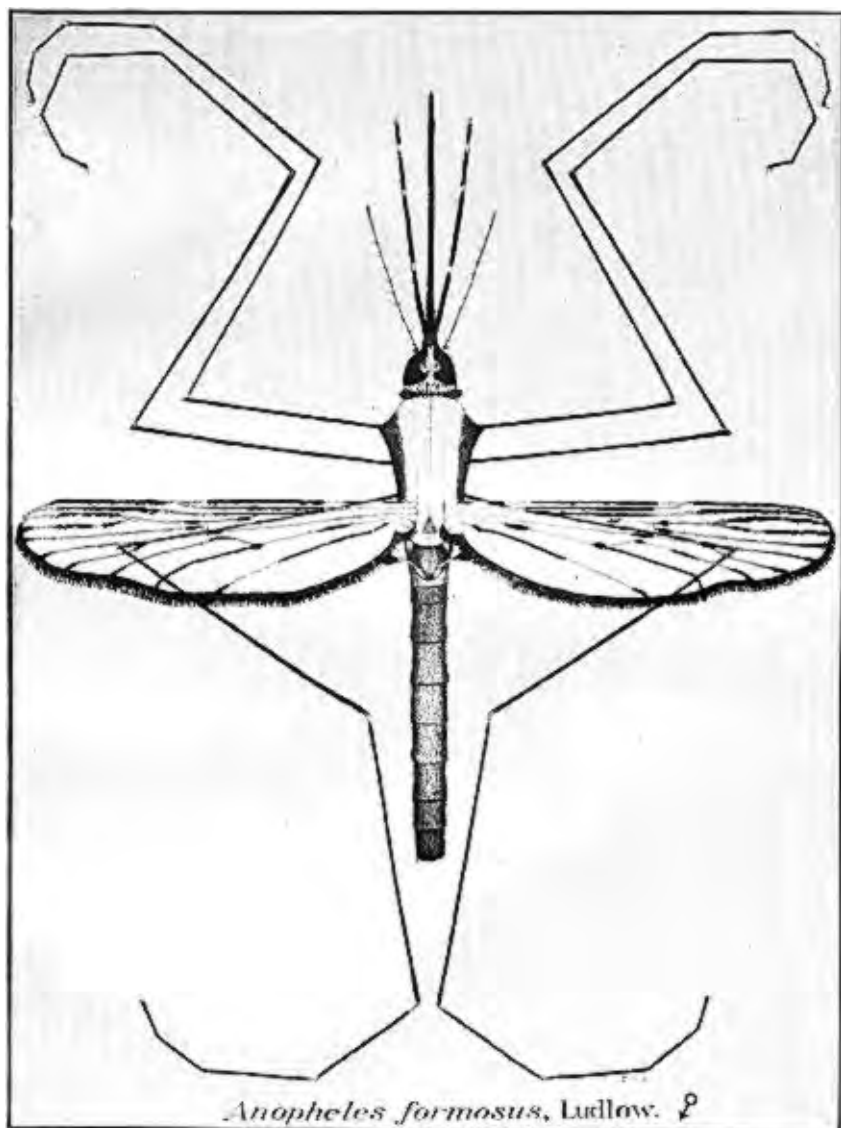
♀. Head brown, with light yellow or white long slender curved scales on the vertex, and projecting forward in a tuft between the eyes, white forked scales on the occiput, and brown forked scales laterad and ventrad; antennæ dark brown, verticels and pubescence brown, basal joint testaceous; palpi brown, rather heavily scaled, the tip light, and bases of penultimate and antepenultimate joints narrowly light-banded, proboscis dark brown, the labella slightly lighter; clypeus brown; eyes dark rich brown.

Thorax beautifully marked; prothoracic lobes dark brown, with dark brown flat (porrect) scales; mesonotum has the median part a light, soft fawn color covered with light yellow or whitish curved hairlike scales extending from the nape to the scutellum, except a small brown median spot just cephalad of the scutellum, and connecting with a dark median line; this median part is bordered with a more or less distinct white line, broadening toward the scutellum; there are also broad submedian yellowish stripes extending from the nape about half the length of the mesonotum; laterad the mesonotum is dark rich brown; scutellum light, continuing the coloring and scales of the medio-mesonotum; pleura rather grayish, with dark and white bands; metanotum rich yellowish brown.

Abdomen grayish brown, covered with long light yellow hairs.

Legs, coxæ, and trochanters light, with a little brown; the very bases of the femora light, otherwise the legs are a rich brown, with yellowish knee-spots and narrow yellowish bands at the bases of most of the tarsal joints, generally slightly including the apices of the preceding joint. These bands are on all the tarsal joints of the hind legs, and lacking on the fourth and fifth joints on the fore and mid legs; ungues simple and equal.

Wings yellowish, with brown spots; two small brown spots on the costa near the base, and two large ones, the proximal including the subcosta and first longitudinal practically as much as the costa, with a small extension on the root of the second long vein, and a still smaller one just under the distal end of the large spot; the distal large spot begins just exterior to the junction of the subcosta with the costa, and ending a little interior to the junction of the first long vein with the costa and extends on the first long and upper fork of the second long vein, with small spots on the lower fork; the distal end of the lower fork of the second, of the third, of both forks of the fourth and of the fifth have heavy dark spots; wing field



Anopheles formosus, Ludlow. ♀

somewhat spotted; fringe is dark except at the junction of the first long vein and costa, where it is yellow, and a pale spot midway between the forks of vein 5; cells long, the first submarginal as long as its stem, and a little longer and narrower than the second posterior cell; supernumerary and mid cross veins meet and are about equal in length, posterior cross vein about as long as the mid and more than its own length distant.

Halteres have light bases, with heavy dark knob.

Length.—10 mm. (proboscis 3.5 mm.).

Habitat.—Camp John Hay, Benguet, P. I.

Taken March 20, 1908.

This large and beautifully marked *Anopheles* is the first of this genus to be received from the Philippine Islands, and shows the characteristic habitat of *Anopheles* in the Tropics, coming from the high mountain regions of Benguet.

Relation to malaria unknown.

Nothing whatever is known of the breeding places, life history, or habits of this mosquito.

22395°—Bull. 4—14—2

ANOPHELES CRUCIANS Wiedemann.

A. ferruginosus Wiedemann (?).

Wiedemann's description of this species is as follows: "Tawny, the thorax with three deeper tinted lines; the abdomen covered with gray hairs; the wings with dusky spots and costa. Length, $2\frac{1}{2}$ lines."

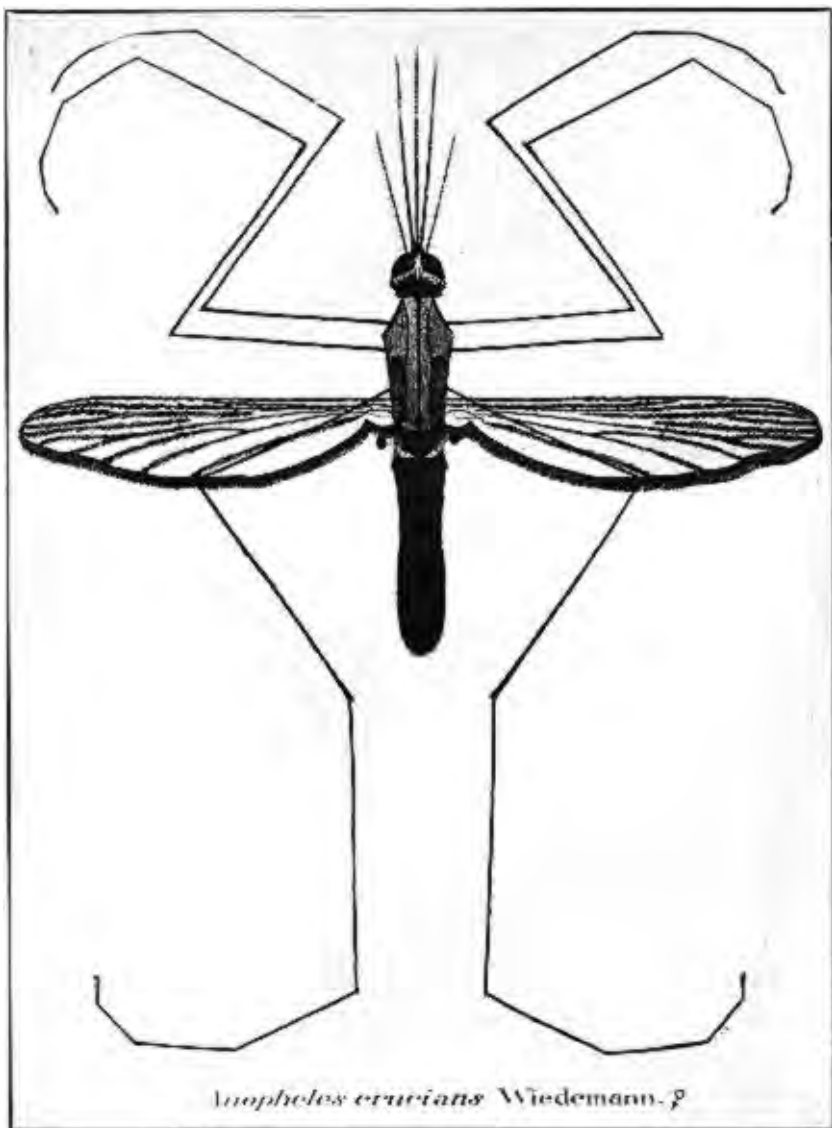
The description by Smith is given below:

"Head dark brown, with scattered yellowish scales at the angles of the eyes and a tuft of yellowish hairs from between the eyes projecting forward over the head. Another line of similarly colored scales forms a border to the posterior margin of the eyes. Proboscis evenly dark brown. Palpi in ♀ dark brown, almost black with apical joint, base of penultimate and antepenultimate joints white. Male palpi dark brown, with the long hairs toward apex yellowish. Antennæ dark brown in the ♀, paler in ♂.

"Dorsum of thorax brown, mottled at the sides with grayish scales and with narrow stripes of scales of the same color down the central parts; pleura and legs same as in *punctipennis*, but the latter not nearly so dark. Wings hyaline, with black, whitish and gray scales as follows: Costa black; subcosta black; radius 1 black; a few white scales at extreme apex, and some grayish ones just before the cross vein between radius 1 and radius 2; radius 2 (second long vein) black, broken twice with white portions before the fork and white again at the margin; radius 3 (lower fork of second long vein), a large portion at base black, a smaller portion black at the margin, intermediate part white; radius 4 and 5 (third long vein) black at the base and again at the margin, grayish and whitish scales between; media 1 and 2 (fourth long vein) grayish to the fork, with a small black patch at the cross vein, after the fork black at both ends, white between; media 3 (lower fork of fourth long vein), black at both ends, white between; cubitus 1 (fifth long vein) white at fork then black to a little beyond cross vein and again at margin of wings, intermediate part white; cubitus 2 (lower fork of fifth long vein) white except a small black patch at margin; anal (sixth longitudinal vein) vein white, a small black portion at each end and one in the center.

"Abdomen as in allied species, dark brown with yellowish brown hairs evenly scattered on the surface.

"Length.—4 to 5 mm."



Habitat.—United States, at the following places: District of Columbia (Pergande); Georgia; New Orleans (Veaye); Richmond, Va. (Slosson). Weidemann says very common on the Mississippi, where it is very troublesome to travelers, and also gives Pennsylvania as a habitat. Cape May County, N. J., and a few other localities there (Delair, Port Reading, Lahaway, etc.); Fort Barrancas, Fla.; Fort Caswell, N. C.; Fort Du Pont, Del.; Fort Fremont, S. C.; Leon Springs and Fort Ringold, Tex.; Fort Monroe, Va.; Fort Screven, Ga.; Jackson Barracks and Fort St. Philip, La. (Ludlow).

Positive to malaria.

The breeding places are probably much those of *maculipennis*, and its larvæ have been taken in brackish water; it is stated that it shows a preference for tidal waters.

ANOPHELES MACULIPENNIS Meigen (1818).

A. quadrimaculatus Say.

A. claviger Fabr. (1805) (no type exists).

Culex bifurcatus Meigen (1804) (?)

Thorax brown, more or less dusky bluish-gray in the center, with a thin central, and lateral dark lines, deep brown at the sides, with scattered golden hair-like scales. Abdomen dark brown, sometimes with tawny-brown markings and dark apical bands, covered with much golden pubescence. Wings with the scales accumulated more densely in four spots—at the bases of the fork cells, at the cross veins, and at the base of the second long vein. Legs brown; femora and tibiæ yellowish-brown below, small pale knee spot; metatarsi and tarsi dark brown.

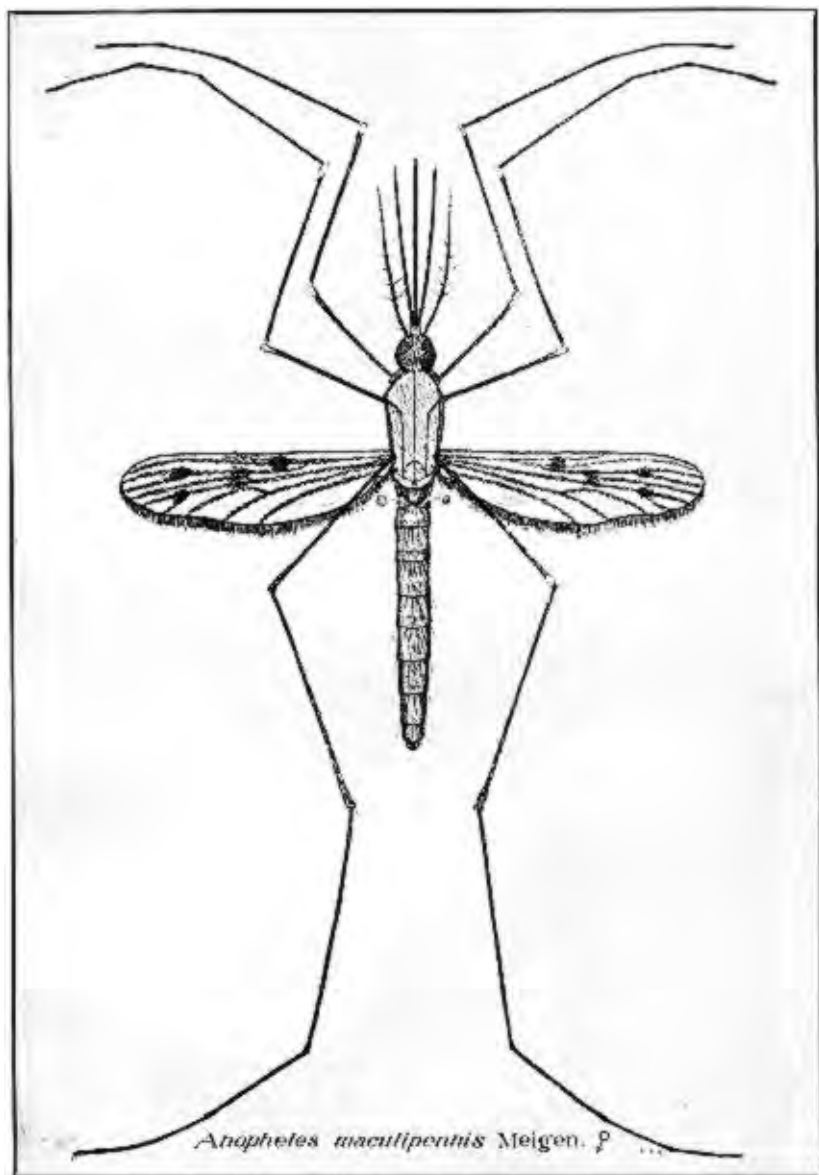
♀. Head with two patches of creamy scales divided by a central line, the rest of the head with black scales, a small tuft of white hairs in front, borders of the eyes white; eyes deep purplish-black; antennæ dark brown, with pale bands and with ferruginous basal joint, pale pubescence and brown hairs; proboscis brown; palpi yellowish-brown, with dense dark scales at the base, which is swollen, shorter than the proboscis.

Thorax brown, more or less dusky bluish-gray in the center, with a thin central, and lateral dark lines, with scattered golden hair-like scales, deep brown at the sides; scutellum tawny at the base, pale gray at the sides, with dark center; metanotum deep reddish-brown; pleura reddish-brown, with paler areas.

Abdomen deep brownish-black, with golden-brown hairs; in certain lights the segments are darkened apically. In some specimens the abdomen has tawny-brown mottlings at the base and the center of the segments, and in others it is brown, with dark apical bands.

Legs with pale coxæ; femora and tibiæ yellowish-brown below, covered with dark-brown scales above; knee spot yellow, apex of the tibiæ paler; metatarsi and tarsi slightly darker than the rest of the legs; ungues equal and simple.

Wings with the veins and margins clothed with narrow black scales, with four black spots formed by scales as follows: At the base of the first submarginal cell, at the base of the second posterior cell, near the base of the second long vein, and another at the base of the third long vein spreading over the three cross veins; first submarginal cell a little longer and narrower than the second posterior cell, its stem half as long as the cell, its base nearly level with that of the second posterior cell; stem of the latter equal to two-



thirds of the length of the cell; posterior cross vein a little behind the mid cross vein, the latter a little way off the supernumerary; apical fringe yellow. Halteres pale, with a black knob.

Length.—6 to 8 mm.

♂. Antennæ banded, plume hairs brown, last joint darker; proboscis black to dark brown; palpi dark brown, the last two joints, which are swollen, have a number of short golden hairs internally and are yellow in color, clothed with thick black scales through which the yellow underground shows, the last joint is ovate.

Abdomen with the segments dark brown centrally and along the hind borders, yellowish-brown at the sides, apical segment and genitalia dark brown; in other specimens the abdomen is tessellated with ochraceous-brown in various ways, the hind borders being always dark. Ungues of the fore legs unequal, the larger with two teeth and a trace of a third near the base, the smaller minute, unsertated, mid and posterior simple, equal and small.

Length.—6 to 7.5 mm.

Habitat.—Europe, in the following countries: Scandinavia (Zetterstedt and self); Austria (Schiner); Germany (Meigen); Spain (Macdonald); Holland (V. d. Wulp); Russia (Gimmerthal); Italy (Ficalbi); England, and France. In Canada it has been found at St. Boniface, Manitoba, and Lake Simcoe, Ontario. It also occurs in New York, New Hampshire, Maryland, Illinois, Florida, Texas, Virginia, New Orleans, Connecticut, etc.

Time of appearance.—In England from March to May and again from June to December. The majority appear in July and August. Females only occur early in the year. E. M. Walker records it in July and September in Canada. It certainly often occurs during winter in Great Britain. In the United States it has been taken during most months of the year.

Positive for malaria.

ANOPHELES OCCIDENTALIS D. and K.

Dyar and Knab call the dark form of the Atlantic coast *quadrimaculatus*, and separate this as a new form, but if the Atlantic coast form be *quadrimaculatus*, it is probable that this is *maculipennis*, the bright ochraceous tip of the wing being the most easily observed difference between the two forms. It is found in the west (California) and as far east, in the northern parts, as Fort Snelling, where it has been taken in great numbers. It is not believed to be concerned in the transmission of malaria.

ANOPHELES ATROPOS D. and K.

It is a very dark form dangerously near *maculipennis*, and is not known to be a host for the malarial parasite. It is reported from the Florida Keys.

ANOPHELES EISENEI D. and K.

A very rare species also extremely near *maculipennis*; is taken in Central America, breeds in the sulci of plants, and is taken in hill streams;¹ is not believed to be connected with malaria.

ANOPHELES WALKERI Theobald.

A dark anopheline without wing spots, and lying close to *A. bifurcatus* L., but with some differences in the ornamentation; it is taken in the Mississippi valley, is comparatively rare and has not been studied in reference to its ability to transmit malaria.

The breeding places of *A. maculipennis* are well known, and may be found in quite fresh, clean water, on the edges of pools or ponds, in the small border eddies of quiet water along running streams or ditches, in hoof marks, small bodies of water in the irregularities of plowed ground, etc. Apparently no place is too small if water be left standing in it for 5 or 10 days, even if there are no algæ discernable. Dr. J. B. Smith also found it breeding in brackish water in marshes.

Comparatively little is known of the breeding place of the others of this group, except *A. eiseni*, which breeds in treeholes and hill streams, often at considerable distance from habitations.

ANOPHELES PUNCTIPENNIS Say.

C. hyemalis Fitch.

Thorax deep chestnut-brown with slaty-gray tomentum in the middle, with pale golden hair-like scales. Abdomen dark brown with golden hairs; legs brown, except the coxæ, the knees and tips of the tibiæ. Costa black with two yellow spots.

♀. Head dark brown, covered with black upright scales, except a small patch of similarly shaped white scales in front; a tuft of white hairs projects forward between the eyes; eyes black with a fine pale border; antennæ brown, with brown hairs and pale pubescence, basal joint very slightly paler; palpi covered with brown scales, rather dense basally and showing a narrow gray band toward the base, a grayish tip and a broader band between, showing only in some lights, in others entirely brown; proboscis brown, with very small scales.

Thorax deep chestnut-brown, with a broad patch of silvery-gray tomentum in the middle, the dark chestnut-brown appearing as a stripe on each side, covered with pale-golden, hair-like scales; in the centre, in front, projecting over the neck, is a tuft of long creamy-white scales; the pale central area shows more or less longitudinal ornamentation; scutellum pale brown, slightly darker in the center; metanotum deep brown; pleura deep chestnut-brown with paler patches.

¹ Darling, S. P.

Abdomen dark brown to almost black, with scattered golden hairs, each segment bordered with long hairs of a similar color; *at the base of the segments there seems to be a constant triangular swelling.* Ventrally the segments seem to be dull grayish basally, due to reflections on the integument.

Legs with the bases (coxæ) almost white; femora, tibiæ and tarsi covered with small dark brown scales; knees and tips of the tibiæ yellow; tarsi with dull purplish and ochraceous reflections under the microscope.

Wings with the costa almost black with two yellow spots, one at the apex and another on the apical third of the wing, the apical spot involving the first long vein and the upper branch of the first submarginal cell, the larger spot passing into the first long vein and the second long vein just before it branches; there is also a patch of pale scales in the middle of each branch of the second fork cell; the sixth long vein is black scaled for about half its length, and again at the base, the middle being pale; all the remaining veins with longish black scales; first submarginal cell longer and narrower than the second posterior cell; fringe black, except at the end of the second branch of the fifth long vein, where it is paler.

Length.—5 mm.; of wings, 6 mm.

Negative to malaria.

This species has always given negative results in experiments in transmission of malaria; the only report to the contrary was made by Dr. Dupree, and it seems to be probable that the mosquito used was *A. franciscanus* instead of *punctipennis*.

It breeds in much the same places as *A. maculipennis*, but where collected near together *maculipennis* was taken from the river edges, and *punctipennis* from spring-fed pools; it has also been found breeding in brackish water in marshes.

ANOPHELES PERPLEXENS Ludl.

Taken at Mount Gretna, Pa., by Maj. Whitmore, Medical Corps, United States Army, is said by Knab to be an aberrant form of *punctipennis*; it is at all events a very much darker form, the large yellow wing spot being reduced to a dot. Only one specimen has been taken, and it is probably of no interest from the disease-bearing standpoint.

ANOPHELES PSEUDOPUNCTIPENNIS Theob.

Wings much as in *A. punctipennis*, Say, but the fringe with yellow spots. Legs long, unbanded, brown, pale at the base. Fore ungues of ♂ unequal, mid and hind equal and simple.

♀. Antennæ brown, basal joint testaceous, base of the second joint pale, and also a small pale band at the base of all the following joints; proboscis dark brown, labella yellowish; palpi dark brown, densely

scaled at the base, apex yellow, and also two narrow yellow bands below, slightly hairy, hairs black, except at the apex, where they are yellow; clypeus dark brown.

Thorax yellowish-brown (denuded), with a dark patch on each side of the mesonotum behind; metanotum deep brown; pleura yellowish-brown, with darker brown patches.

Abdomen brown, the segments paler at the base; hairy.

Legs deep brown; coxæ, trochanters, and base of femora pallid; knee spot pale; unguis equal and simple.

Halteres with pale stem and fuscous knob.

Wings with two yellowish-white spots on the upper costal border, rest of the edge black, rather densely scaled; first submarginal cell longer and narrower than the second posterior cell, its stem nearly as long as the cell; mid cross vein a little nearer the base of the wing than the supernumerary cross vein; posterior cross vein still nearer the base of the wing; scales of the wings disposed as follows: First long vein with three distinct large white spots, one at the base, one underneath the large costal spot, and one between; second long vein with a dark patch near its base, all the lower branch of the fork cell dark, and most of the upper; third long vein mostly yellowish-white, with two black patches, one toward the base, the other toward the tip; fourth long vein mostly pale, with two small black patches, branches of the fork cell all dark scaled; fifth long vein with a black spot near the base, rest mostly yellow, upper branch of the fork mostly dark, a small yellow spot at the apex and another toward its base, lower branch mostly yellowish, with a black apical spot; sixth vein with the basal half creamy, the apical half dark, except a small yellow patch where it joins the wing border; fringe brown, with a yellow spot at the junction of each vein.

Length.—5 mm.

♂. Last two joints of the palpi swollen and clavate, pale, basal joints dark brown, densely scaled with deep brown scales, with a narrow pale band, not quite as long as the thin proboscis, which is brown, with yellow labella; antennæ gray, with narrow brown bands and flaxen brown hairs, the apical joint about half the length of the penultimate joint; basal lobe of the genitalia simple, claspers long and thin; fore unguis unequal, the larger one uniserrated, the smaller minute and simple; mid and hind unguis small, equal and simple.

Wings much as in the ♀, but the fork cells shorter.

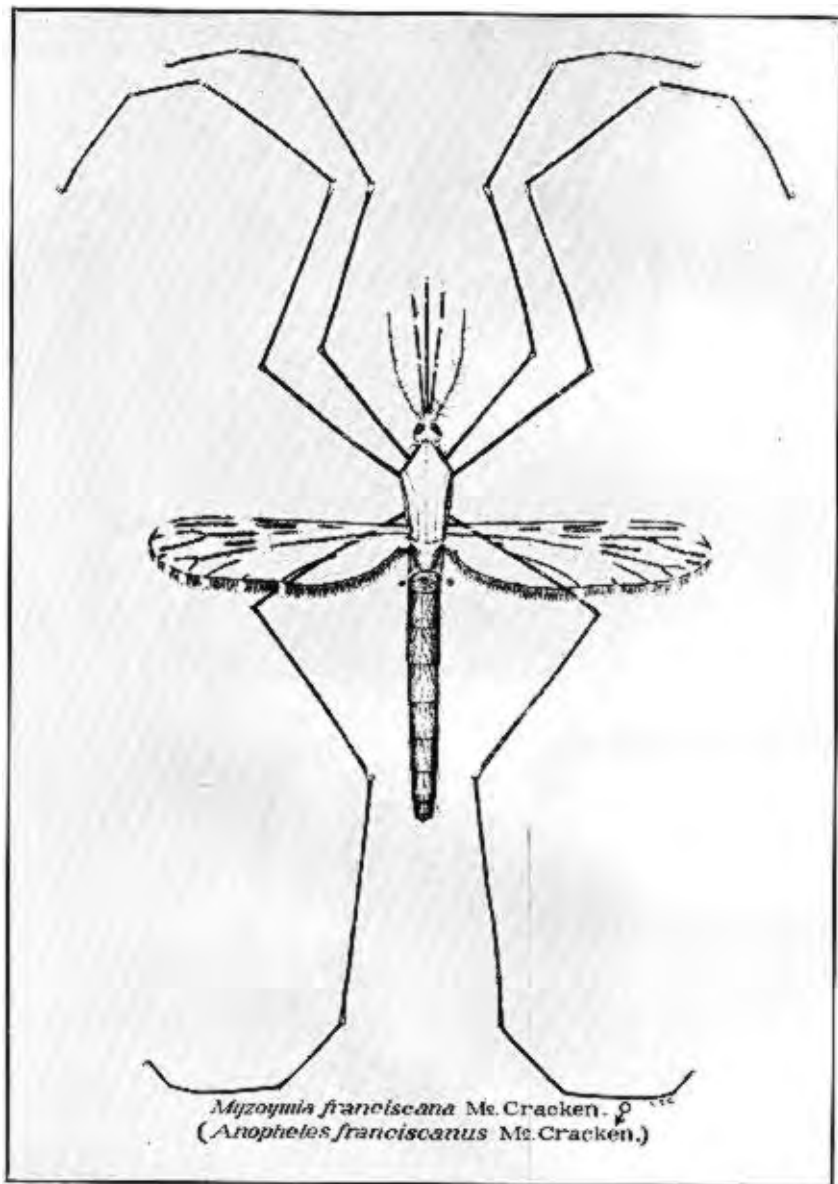
Length.—5 mm., with proboscis 7.5 mm.

Habitat.—Grenada (Dr. Hatton, per Dr. Daniels); also in the Southern States of the United States, but rather rare.

Time of capture.—February.

Proven host for malaria (?).

Breeding places not well known.



ANOPHELES FRANCISCANUS McCracken (1904).

Head dark brown; palpi brown with light bands. Thorax dark brown at sides, pale in the middle, with median and obscure lateral lines. Legs unbanded. Wings with dark costa with two nearly equal yellow spots and a pale spot at end of each vein of fringe except sixth; rest of veins yellow and black.

♂. Head dark brown, with short dark erect scales toward the nape, emarginate and slightly forked, vertex and anterior part of occiput with short, light-brown scales not forked, a tuft of light-brown hairs projecting forward encircling the eyes posteriorly; eyes deep purplish brown; antennæ about two-thirds length of palpi, yellowish-brown hairs, basal segment dark brown; palpi equaling proboscis in length, with emarginate scales from base to tip on under and outer surfaces, those upon outer surface dark, upon under surface light, long light hairs covering distal third, becoming short at the apex; a light area at base of three distal segments, giving a slightly banded appearance; two distal segments spatulate, proboscis scaled except labella; labella covered with median stout setæ, a few light hairs at apex.

Thorax, prothoracic lobes dark; mesothorax dark brown at sides, with scattered light hairs, a broad light-brown patch in the middle; within this light area a median line and obscure lateral lines; scutellum light with single horizontal row of hairs; metanotum dark without hairs; halteres dark covered with thick pubescence and emarginate scales, stalks light without scales.

Abdomen, basal area of each segment light, covered sparingly with long, light hairs; two stiff hairs on posterior margin of distal segment, stout hairs on margin of genital lobes.

Legs, coxæ, and trochanters light, the latter, femora, tibiæ, and tarsi covered with short, dark emarginate scales and setæ; ungues of front legs very unequal, the larger ones with a large median tooth and small basal lobe; median ungues curved, with blunt basal lobes; posterior ungues equal, simple; posterior metatarsus slightly longer than tibia.

Wings with dark costa, with two distinct, nearly equal, yellow spots, one at distal end of subcostal vein, one at and involving distal end of first long vein; fringe dark, with a yellow spot at the end of each vein except at the end of the sixth; the first spot carried on to the first long vein, the apical spot carried past over long vein on to the upper branch of the second long vein; the second long vein

dark except for a few basal light scales; third long vein yellow in the middle, dark at the base and apex; light area at base of third long vein carried over the fourth on to upper branch of the fifth, with a few light scales at base; main branch of fifth long vein light, except at base and apex; distal half of sixth dark, except at apex, basal half light; subcostal with a light spot carried to the first long vein (in one specimen the light spot on subcostal missing); third long vein prolonged into basal cell; first submarginal cell longer and slightly narrower than the second posterior cell, stem twice the length of the cell; stem of second posterior cell prolonged to base of wing; super-numerary cross vein adjacent to or but very shortly removed from mid cross vein and equal to it in length when removed nearer to apex of wing; posterior cross vein a little longer than mid cross vein and varying in distance from it from one-half to almost twice its own length; third long vein prolonged slightly into the basal cell, darkest scales on costal, subcostal, and first long vein.

♀. Palpi equaling proboscis in length, light area at base of three distal segments, giving a banded appearance, clothed with scales, short hairs, and setæ as in the ♂, distal segments not spatulate; legs with unguis equal; otherwise agreeing with the male.

Localities.—Fort Brown, Fort Clark, Fort Sam Houston, Leon Springs, Texas; Benecia Barracks (Ludlow); California (McCracken and Ludlow).

Proven host of malaria (?).

Knab believes this species to be identical with *A. pseudopunctipennis*, and in that case this species sinks as a synonym. However, both descriptions have been given because no one is sure which mosquito Dr. Dupree actually worked with, and it is possible there are two species, and one or both have probably been shown to develop the malarial parasite. There should be more extended study of these species and their relation to malaria.

Genus, **MYZOMYIA** Blanchard.

(*Grassia* Theob.)

(Mon. Cul. III, 24.)

Thorax and abdomen with hair-like curved scales; there may be a few narrow-curved ones on the front of the mesothorax, forming a tuft, projecting over the head; wings with mostly long thin or narrow lanceolate lateral vein scales; the wings are spotted, and they are usually small or moderate size species.

The larvæ live mostly in flowing water, rarely in ponds or stagnant water, except *Rossii* and *superpictus*, which may live even in pots and puddles.

MYZOMYIA ROSSII Giles.

(Gnats or mosquitoes, 2d ed., 311.)

Wing with the costa pale at the apex and base, but generally black, interrupted by two large yellowish spots opposite the fork cells, and just in front of the cross veins, respectively; the black area next internal to these is very large and is T-shaped, owing to the presence of a short length of black upon the second long vein beneath the middle of the thrice longer area on the costa and auxiliary; internal to this there are only three minute white ones; there is a row of sub-apical black dots on every one of the long veins, and three or four others, and the fringe is yellow at the tip, and has pale patches at all the longitudinal junctions, except that of the fourth. Tarsi with yellowish rings on all but the last articulations of the fore and mid legs. Thorax deep brown, with, in the fresh state, a dorsal, tun-shaped patch of velvety, pale cinerous bloom. Abdomen dusky, nude, finely clothed with golden-brown hairs.

♀. Head blackish, with pale scales in front, and with a tuft of pale hairs projecting forward, black scales at the top and sides; eyes black, antennæ brown, with pale hairs and pubescence, basal joint ochraceous brown, with a few creamy scales; proboscis dark brown, apex sometimes pale; palpi dark scaled, apically white, and with two other pale bands near the apices of the second and third joints; clypeus pale brown.

♂. Palpi swollen at the end, yellow, with a broad black band at the base of the second joint, a broad black band at the base of the third, and a small one near the apex of the same joint, and narrow ring of black at the base of the last two joints; hair tufts short, pale;

the base of the palpi densely black scaled; proboscis dark brown, pale at the tip; antennæ with silky golden-brown plumes.

Wing marked much as in the ♀, but in many ♂, especially in those from south India, there is a small additional spot beneath the second costal spot, besides the one forming the T.

According to Dr. Daniels it does not carry the tertian crescent stages of the malarial parasite.

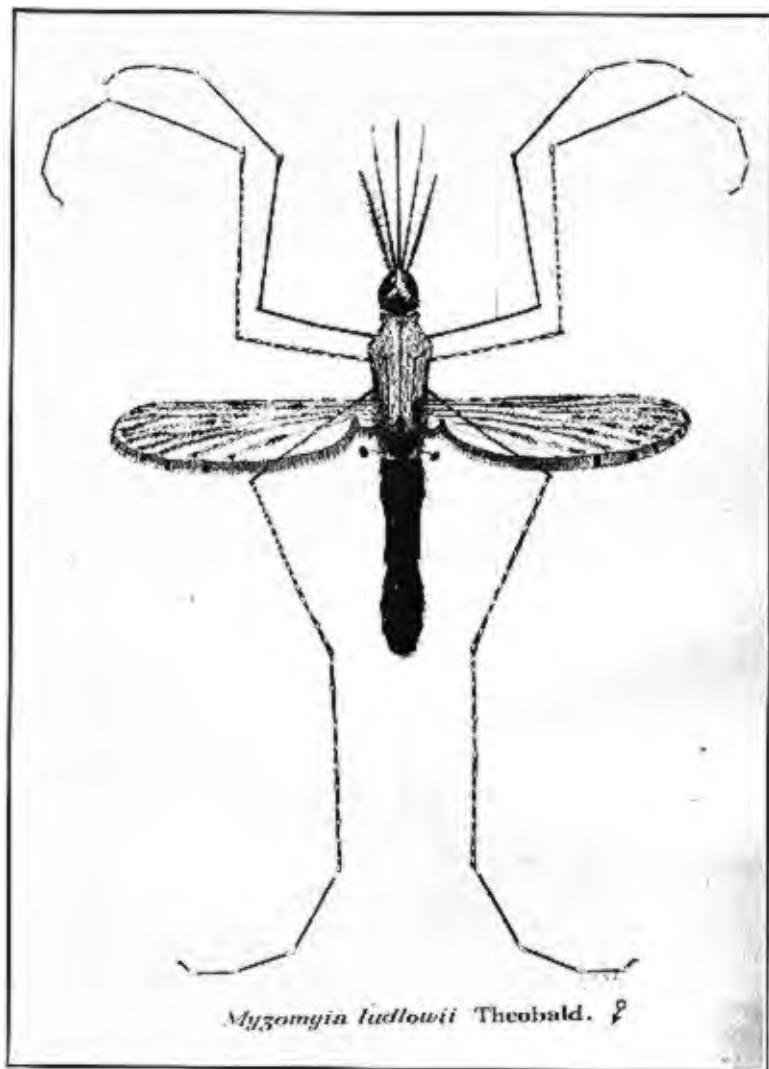
Length.—4.6 mm. ♂. 6 mm. ♀.

Host for *Filaria bancroftii*.

Relation to malaria probably negative. Christophers examined about 100 specimens, all of which were negative.

Habitat.—Common throughout India, but comparatively rarely taken in the Philippine Islands.

Breeds in small water holes of fresh water, and also in brackish water.



MYZOMYIA LUDLOWII Theob.

Palpi deep brown, the apex broadly white banded, another small band close to it, and a third much lower down; proboscis deep brown, with distinct creamy white tip. Thorax fawn-colored in the middle, dark brown at the sides, with median and lateral dark lines and narrow curved hair-like pale scales; abdomen brown, with pale hairs. Legs mottled and spotted with yellow; tarsi apically and basally pale banded. -Wings with four large costal spots and two small basal ones; most of wing area pale scaled.

♀. Head pale brown, with narrow pale scales and pale and brown upright forked ones, a pale median tuft projecting forward; antennæ brown, basal joint pale ferruginous; proboscis deep brown, apex creamy; palpi deep brown, with a broad creamy apical band, and near



FIG. 18. ♀ Wing of *M. ludlowii* Theob.

it another narrow pale band, the remainder divided by a narrow pale band, base densely dark scaled.

Thorax fawn-colored in the middle, dark brown at the sides, with a median dark line and a narrow dark line on each side of the pale area, with scanty hair-like curved pale scales and traces of a dark spot before the scutellum, which is pale brown, with narrow hair-like scales; pleura brown mottled with gray.

Abdomen brown, with narrow curved hair-like scales and pale posterior border-bristles.

Legs brown, the femora and tibiæ and metatarsi, especially in the hind legs, spotted with yellow; tarsi with broad apical and basal pale banding, especially on the hind legs; ungues small, equal, and simple.

Wings with four large dark costal spots and two small basal ones, the apical spot small, extending evenly on to the first long vein; this is followed by a pale area nearly twice as long as the black apical spot.

The second black spot is about the same length as the preceding pale one and spreads evenly on to the first long vein; the next pale area is slightly longer. The third black spot is the largest, and spreads nearly evenly on to the subcostal vein, while beneath it on the first longitudinal is a large black line and then a small pale area followed by a small black spot, the black line not beginning directly under the costal spot. The fourth black spot is separated from the third by a very small pale area, and extends evenly on to the subcostal and first longitudinal; at the base is another small black spot. The second long vein has dark scales on each side of the cross vein and a dark spot on the upper branch of the fork cell under the apical costal spot, and another small one near its base; the lower branch has an apical spot and a larger one near its base. The third long vein has a black apical spot and a dark patch on each side of the cross vein; the fourth is mainly dark on each side of the cross veins, and has two dark spots on the upper branch, one near the base, and two on the lower branch;



FIG. 19. ♂ Wing of *M. tudlowii* Theob.

the fifth has a black spot at its root, three on the upper branch, and one at the apex of the lower branch; the sixth has two dark spots. The first submarginal cell is a little longer and decidedly narrower than the second posterior cell, its base slightly nearer the apex of the wing than that of the second posterior cell, its stem as long as the cell; stem of the second posterior considerably longer than the cell; supernumerary and mid cross veins in one line, the posterior rather more than twice its length distant from the mid, but very variable, sometimes step-like; fringe with pale spots.

Length.—4 to 4.8 mm.

Habitat.—Widespread in the Philippine Islands, Malay, Andamans, etc.

Time of capture.—April (of type).

Observations.—Described from a number of specimens. A very variable species, somewhat like *rossii* at first sight, but easily told by the spotted legs and much shorter fork cells. The base of the first submarginal is always slightly nearer the apex of the wing, and the

costal spots differ slightly, but are to some extent variable. The cross veins are most unstable. The palpi are very similar, but the apical band in *rossii* is rather longer. The chief difference is that in *rossii* the second white band is a third of the way down the palpi; in this species it is less, and the black intervening area is much smaller.

The reports as to the ability of this mosquito to carry malaria are contradictory. Banks, working in Luzon, considered that it carried malaria; Ashburn and Craig, working in the southern islands, found it negative; Christophers¹ found it positive in the Andamans, reporting "zygotes of malignant tertian" in 2 out of 33 specimens examined, and believes it to be the important carrier of malaria in the settlement; Watson² believes it negative in the Federated Malay States. It is possible that two species are concerned and have been confused, for this group contains several species that are closely related and easily mistaken one for the other. Relative to this Christophers says (p. 10): "It is interesting to note that though *Nsm. ludlowii* rather closely resembles *Nsm. rossii*, the eggs of the two species are quite distinct, those of *Nsm. rossii* having a very broad frill, whereas those of *Nsm. ludlowii* have a narrow frill and rather resemble in general appearance the eggs of *N. fuliginosus*."

There is also some controversy as to the breeding places of this species. The original specimens on which the species was founded were taken in Abra, Luzon, on the "Benguet road," a definitely inland location, which is too far removed from salt water to make it likely that these specimens were bred in brackish water. Many specimens were taken at Orion and Naic, on Manila Bay; Banks believed it to breed indifferently in fresh or salt water; Dr. Stitts tells me he has often taken it from brackish water; Dr. Watson told me he had taken it from water where the per cent of salt was relatively high; and Christophers says he has taken it where the salt was roughly determined as about 0.4 per cent, and did not find it inland. Here also the suggestion is made of two species, and while this is possible, perhaps probable, it must be remembered that in the later study of anophelines it has been found that they are by no means so fastidious in the breeding places as at one time supposed. *A. maculipennis*, *punctipennis*, *crucians*, *M. rossii*, *C. albimanus*, and *C. tarsimaculata* are all known to breed in brackish as well as fresh water, and *M. indefinita* will breed in soiled water, so that it is quite believable that *M. ludlowii* may breed in either salt or fresh water. The question of its relation to malaria is much more important, and the question as to species becomes interesting from that standpoint.

¹ Christophers, S. R. Malaria in the Andamans. Sci. Mem. by officers of Med. and San. Depts. of the Govt. of India. (New series.) No. 56.

² Watson, M. Prevention of Malaria in the Federated Malay States.

MYZOMYIA DECEPTOR Dönitz.

(*Myzomyia thorntonii* Ludlow.)

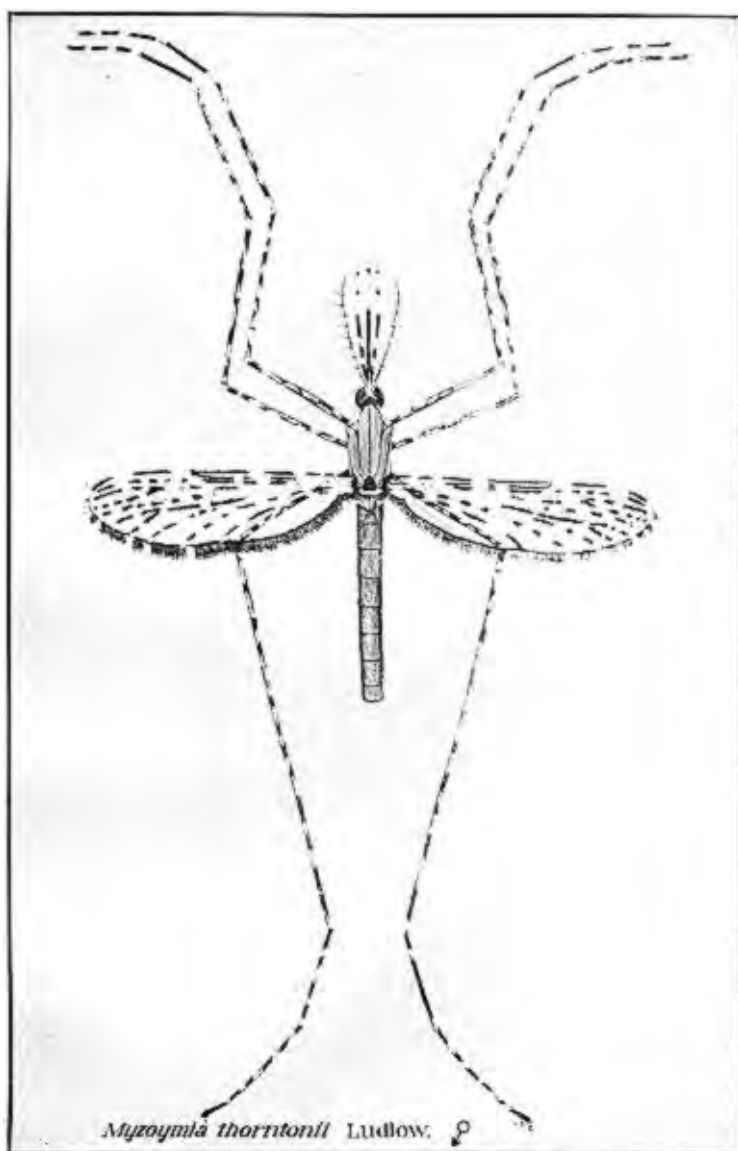
♀. Head dark brown, with tuft of white scales on the vertex, and white hairs projecting forward between the eyes, a few white scales around the eyes; antennæ brown, verticles and pubescence white, basal joint testaceous, a few white scales on first and second joints; proboscis brown on basal half, apical half dull yellow, with narrow brown band at apex, tip dull yellow; palpi, ultimate joint white with narrow basal brown band, penultimate also white with narrow basal brown band, followed by a broad white band, and the remainder of the palpi brown, divided nearly in half by a narrow white band. About the middle of the exterior brown section is a small yellow spot, and there are a few yellow scales near the base of the palpus. Eyes brown; clypeus brown.

Thorax light brown, with white (frosty) tomentum, and a dark median line, and the whole sparsely covered with golden-brown hair-like scales and a few flat white ones on the cephalad end; prothoracic lobes with brown flat scales; scutellum light laterally, and broad dark median line, hair-like golden-brown scales and brown bristles; metanotum brown.

Abdomen very dark brown, rather heavily covered with brown (golden brown in some lights) hairs.

Legs: Coxæ and trochanters all brown, with a few white scales; femora and tibiæ all dark brown, with distinct white spots (6 or 7) on the sides; first tarsal joint on fore legs basally and apically white banded, and a few white spots, and all but the fifth tarsal joints basally and apically white banded, so as to make rather broad bands; last joint brown, but giving light reflections; first tarsal and all the other tarsal joints on the mid leg have narrow white apical bands; sometimes the first tarsal joints have white intermediate spots, and sometimes the band on the last joint is lacking; on the hind leg all the tarsal joints, except the last, have narrow white apical bands and one or two white spots. These tarsal spots vary greatly in individuals, there being sometimes only one small spot, sometimes several, and sometimes the first tarsal spots are very large, so as nearly to cover the apical half of the joint. Oddly enough this occurs in one specimen on one leg and not on the other. Ungues simple and equal.

Wings markedly spotted, costa mostly dark, a light spot at the apex extending on apex of first longitudinal and upper fork of second long vein, a second spot a little exterior to base of second poste-



rior cell, a third at the junction of the subcosta, a fourth at some distance from the third, and two or three small ones near the base of the wing. The large spots all extend on the first longitudinal, and there are additional white spots on the first long vein in the area between the third and fourth costal spots, and sometimes between the second and third costal spots, but so irregularly placed as to be of little value for identification, the two wings of the same insect varying markedly. The wing field is well spotted, about six light spots on the third longitudinal, and the other veins spotted in much the same way except the stem of the second posterior cell, which is dark. Fringe is mottled, the light spots occurring for the most part at the apices of the veins; on the inner (short) fringe scales the light spots occur as far as the sixth longitudinal, on the long scales the spots are distinctly yellow as far as the fifth longitudinal, and merely pale at the apices of the more caudal veins; first submarginal cell longer (4:3) and narrower than the second posterior, its base nearly



FIG. 20. Wing of *M. thorntonii* Ludl.

one-sixth of its length interior; stem of second posterior much the longer; supernumerary cross vein is nearly equal to mid, which it meets, and posterior cross vein somewhat longer and a little more than its own length distant. These vein positions vary somewhat; halteres white.

Length.—3–3.3 mm.

Habitat.—Oras Samar, P. I., and Cotabato, Mindanao, P. I.

Taken June 20 (Cotabato), August 20 (Oras).

This is a very beautiful and well-marked species near *M. albirostris* Theobald, but the additional broad band on the palpi and the spotted legs make it easily distinguishable, while the wing markings resemble those of *M. elegans* James. The two specimens from which the description was written were collected by Dr. James W. Thornton, contract surgeon, United States Army, after whom it is named, and it occurs rather infrequently.

Relation to malaria unknown. Nothing at all is known as to the breeding places or life-history of this species.

MYZOMYIA INDEFINITA Ludlow.

(*Myzomyia Rossii*, Giles; var. *indefinita* Ludlow.)

♀ Head brown, covered with white curved scales on the vertex, some large ones projecting forward as a white tuft between the eyes, white forked scales on the occiput, brown on the sides; antennæ brown, verticels and pubescence white, basal joint testaceous; palpi brown, last joint broadly white tipped, a narrow white band near it, and another dividing the remainder of the palpus in half (very like



FIG. 21. *M. indefinita* Ludl.

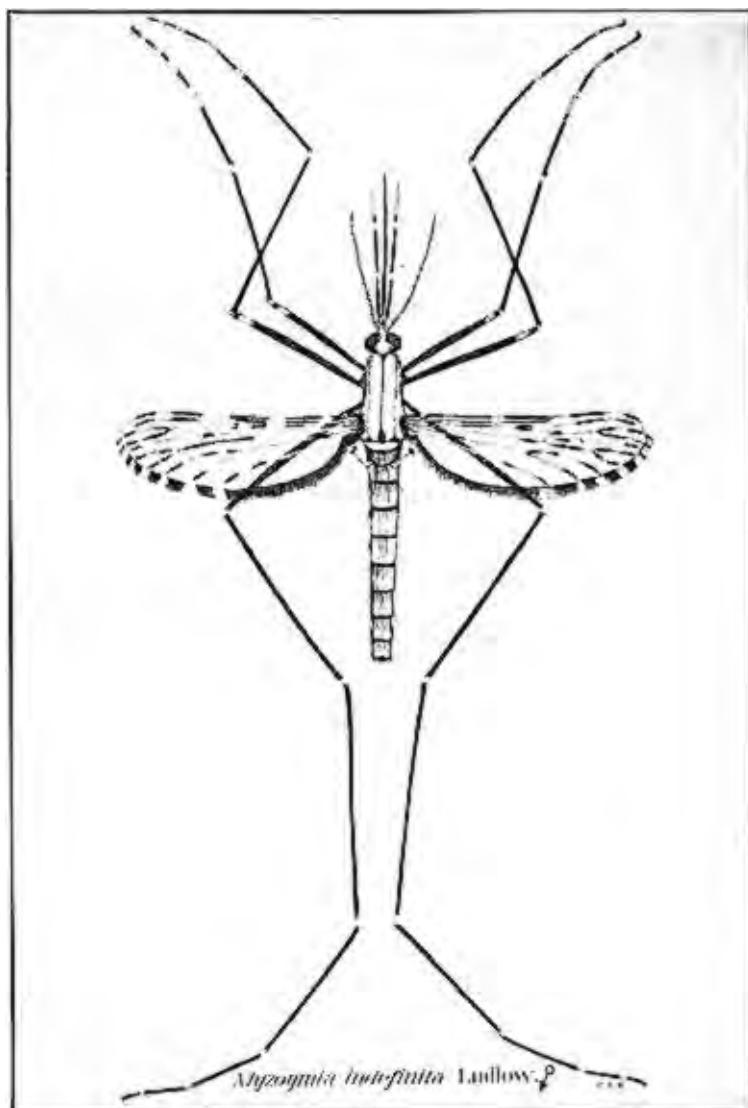
Ludlowii), basal part dark and quite heavily scaled; proboscis dark, tip light; eyes brown; clypeus brown.

Thorax gray and sparsely covered with slender hair-like curved white scales, and a few heavier ones projecting forward at the neck, a dark median line, widening just cephalad of the scutellum so as to form a small spot, narrow lateral ridges appearing as dark lines, running from the scutellum about half the length of the mesothorax; scutellum with hairlike white scales; metanotum brown; pleura gray, with brown spots almost forming bands.

Abdomen gray, densely covered with golden hairs.

Legs: Coxæ and trochanters white scaled, with dark tips, so as to form a light band at base of leg; femora all brown, a subapical yellow band on the fore femora, the tip dark; this marking sometimes occurs on the other legs and sometimes is wanting on all; tibiæ brown, with a narrow apical yellow band; first tarsal the same, and the other joints on fore and mid legs basally and apically banded except the last joint, which lacks the apical band; ungues simple and equal. All the tarsal joints on the hind legs have usually only minute apical bands, but occasionally the tarsal bands involve both joints.

Wings light, heavily covered with dark and light scales forming on the costal portion spots as follows: Apex light, extending on tip of



first longitudinal and upper branch of second longitudinal, then a short dark spot, which includes first longitudinal and upper branch of second longitudinal, followed by a light spot, about one-third longer than the dark, and extending also on first longitudinal; second dark spot about as long as the preceding one, and extends on first longitudinal, then a light spot followed by the third dark spot, which is much the longest of the dark spots, includes the subcosta its full length, and extending on the first in the center, suggests the T of *Rossii*; there is also at times a second dark spot on the first longitudinal under this long one (like the marking in *Ludlowii*), and the relative lengths of all the costal spots vary so much that no measurements can be depended on. The fourth spot is shorter again, and extends on the subcosta and first longitudinal. A couple of small indefinite dark spots on the costa only at the base of the wing. The wing field reminds one strongly of *Ludlowii*, and is fairly stable; first submarginal is slightly longer and about the same width as the second posterior cell; bases nearly on a line, and the cells are noticeably longer than those in *Ludlowii*, in which this species resembles *Rossii*. Supernumerary cross vein about half the length of the mid, which it meets, and posterior cross vein is also about the same length, and about two and one-half times its length from the mid. Halteres light, knob fuscous. Fringe mottled, light at apex of cells.

Length.—3.5 mm.

Habitat.—Philippine Islands. Widespread; taken May (Bayamban), September (Mangarin), December (Guimaras Island), etc.

This species occurs with *Ludlowii* at various places, and until Mr. Theobald called my attention to the differences I believed it to be *Rossii*, which it strongly resembles. The general coloring is, however, darker, in this resembling *Ludlowii*, and its great variability makes it extremely hard to place definitely. Its relationship to these two species may be indicated as follows:

Wing venation like *Rossii*, and is constant. Palpi markings and general color like *Ludlowii*, also constant. Femoral markings (when present) like *Rossii*, never like *Ludlowii*. Wing markings extremely variable, and may resemble either species. The balance seemed to lie in favor of *Rossii*, and I therefore referred it to that species, but longer acquaintance with it leads me to believe it is distinct, and should never have been so referred.

Probably negative to malaria.

Christophers in the Andamans, found it usually breeding in small and temporary puddles among the houses, occasionally in small clay puddles on the hilltops, and never in rice fields and such pools as one would expect to find them in. In the Philippine Islands the larvæ have been taken in ditches carrying the soiled soapsudsy water from the bathhouses.

MYZOMYIA FUNESTA Giles.¹

(Addendum 1. Report at Liverpool Malaria Exhibition.)

Wing spotted, with a very distinct apical spot, and three large ferruginous interruptions of the intensely black (or dark brown) costa, which, however, are much shorter than the length of black separating them; the two outer of these involve an equal length of I (first long vein), but the innermost is nearly twice as long as the costal portion of the spot, being as long as the black interval in front of it, instead of being but half its length, as is the costal portion of the spot in front of it; there is an additional yellow spot midway between the innermost distinct spot, and the base of the wing, but it does not involve



FIG. 22. Wing of *M. christophersi* Theob. (*M. funesta* Ludl. non Giles).

the absolute margin of the costa, which is black. Saving small patches on the three bifurcations, the rest of the wing is mainly black,

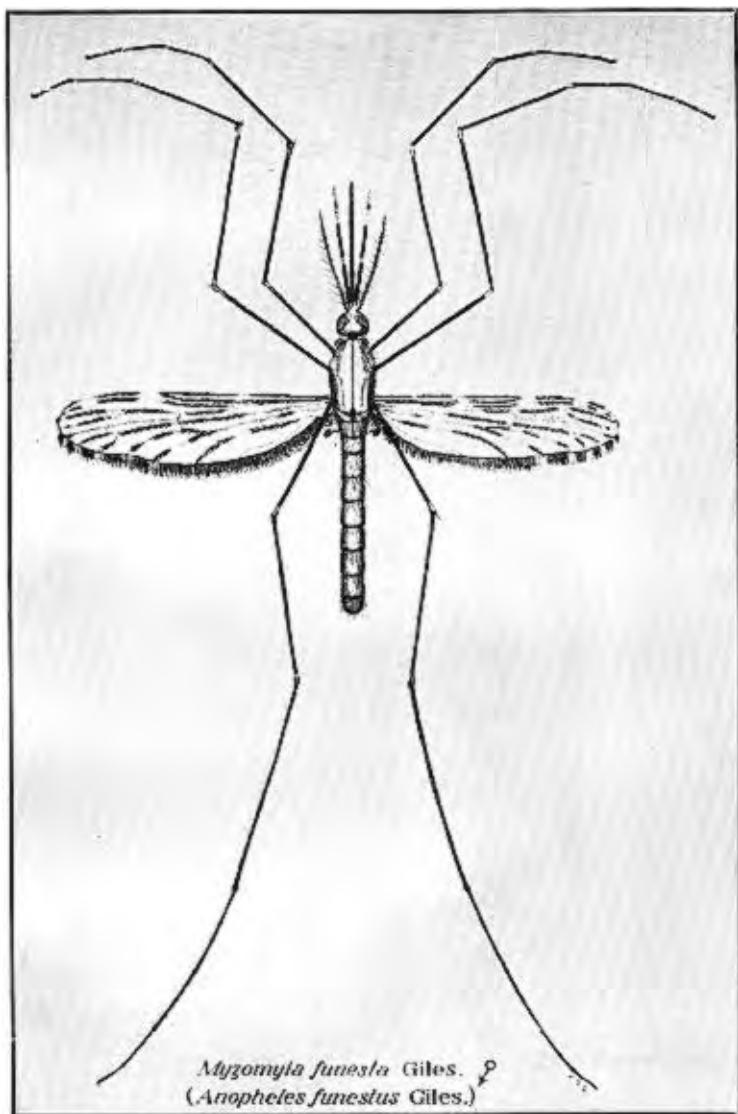
¹ When the first specimens of this Anopheline were received, determined as *A. funestus* Giles (*M. funesta*) and the determination confirmed by Mr. Theobald at the British Museum, none of the nearly related species had been described, and since that time it has very naturally been reported as "*funesta*." Lately specimens have been sent to the British Museum for further study, and Mr. Edwards now writes me that these Philippine specimens are not the African *funesta*, but one of the nearly related forms which occurs in India.

What the proper name for the species is seems a little clouded. Edwards says "*christophersi* (= *alboapicalis* Theob. = *mangyana* Banks = *funesta* Ludl.) is distinct from *listoni* Liston," but James and Liston claim that *christophersi* and also *fluvialis* are merely synonyms of *listoni*. However, if the colored plate (the Anopheline Mosquitoes of India, new edition, James and Liston) be correct, then *listoni* is not the Philippine species, for the two more apical white palpal bands are much heavier in the Philippine specimens, and it seems probable this should be referred to *christophersi* Theob. To this synonymy there probably must be added *M. flavirostris* Ludl. lately published and covering only the dark form of the species. Edwards writes that the specimens of this species in the British Museum "are fortunately in good condition. The type of *christophersi* has two broad apical bands like your *funesta*. (The third band is narrow.—C. S. L.) On the other hand, both *funesta* Giles and *listoni* Liston have female palpi with three narrow bands."

The type specimens were taken at Duars; the larvae are common in rice fields; the adults in sheds where goats or cows had been kept, and Theobald says "it is a prominent malaria carrier."

The above description is, of course, not that of *christophersi*, but the accompanying plate and the photograph of the wing represent *christophersi*. The description of *M. flavirostris* given below is that for the dark form of the species, the usual coloring being a soft reddish brown.

It is interesting to note that Dr. Watson writes that *listoni* is not found in the Federated Malay States, and *christophersi* is probably either not there or has been reported under another name.



Myzomyia christophersi Theob. (*M. funesta* Ludl. non Giles).

but the entire tip of the wing fringe and spots opposite all the longitudinal junctions, but that of VI, are yellow. Tarsi entirely black. Thorax and abdomen jetty black, with scattered golden hairs.

Head black, with distinct snowy frontal tuft, the fork scales of vertex and occiput all white; palpi ♀, as long as proboscis, sooty with a longish white tip, and two snowy bands, the outer of which is much the broader; the ♂ has merely irregular gray patches on the club. Antennæ ♀, black, with silvery verticels and some white scales on some of the basal joints. In certain lights there are some indications of five bare lines on the curious powdery bloom so common on the thorax of mosquitoes of this genus. Halteres with yellow stems and black tips. The male has the apices of the abdominal segments darker, owing to much powdery bloom on their basal portions.

Length.—2.5–3 mm.

Habitat.—Sierra Leone, Mashonaland, British Central Africa, up to 5,600 feet above the sea level; Lake Chilwa, British Central Africa; Zomba, Philippine Islands.

The coloring in the Philippine specimen is more often a very dark brown than “sooty.”

Positive for malaria.

It is usually reported as taken in small pools, but James¹ says it belongs to a group of anophelines which breed in small eddies at the sides of streams having considerable current, and that these breeding places are often overlooked and entirely neglected.

MYZOMYIA FLAVIROSTRIS, Ludlow.

♀. Head dark, covered with dark brown and white forked scales, and white long slender scales on the vertex, extending forward as a long tuft; antennæ brown, verticels and pubescence white, basal joint brown but not so dark as the cephalic scales; palpi dark brown, the ultimate joint white except a very narrow brown basal band extending as a tiny brown band on the apex of the penultimate, a broad white band on the base of the penultimate and the apex of the following joint, the remainder of the organ dark brown, except a very narrow white band, at the base of the preceding joint, very heavily scaled at the base; proboscis light scaled on the apical half of the ventral side, but this rarely shows on the dorsal side, the proximal half dark brown, very heavily scaled at the base; clypeus dark brown; eyes dark brown.

Thorax: Prothoracic lobes dark, with brown chaetæ; mesonotum has the median third of a light brown, sometimes almost yellowish, covered with the fine tomentum so often found on Anophelines, and sparsely with golden brown hair-like scales, a well-marked dark median line broadening so as to cover the “bare space,” and in some

¹ James, S. P., and Liston, W. G. Anopheles Mosquitoes of India.

specimens suggestions of other laterad dark lines, a bunch of long white slightly curved scales extending over the nape; the lateral parts are a rich dark brown. Scutellum dark brown in the median portion, lighter laterad; metanotum dark; pleura almost black.

The abdomen is very dark, almost black, with scattered brown to golden-brown hairs.

Legs: The coxæ and trochanters are dark, covered with small dark scales and chaetæ; femora of the fore legs light brown, tibiæ and tarsi darker brown, unguis simple; mid-femora light brown, the rest of the leg dark brown, but the terminal tarsal joint appearing fawn-colored in some lights, unguis simple; hind femora light brown, tibiæ much darker, especially toward the apex, and some specimens showing a tiny white apical spot, all the tarsal joints brown, sometimes with a suggestion of apical light spots on the third and fourth joints.

Wings clear, covered with brown and light yellow scales. The costa as a whole is dark with five small light spots, one at the apex of the first long vein, one extending on the first long about on a line with the base of the second posterior cell, the third also extending on the first longitudinal is well interior to a line through the base of the fork of the fifth long vein, and the last is a tiny spot between this and the root of the wing. The wing field has many small spots; the third long vein is mostly light, with a small dark spot at its apex and one near its base; there are light spots at the fourchette of each fork cell; the stem and lower fork of the fifth long vein are mostly light, a dark spot at its apex and one at the base of the cell, the distal half of the upper fork of the fifth long vein is white with a very small dark spot at the very apex; the sixth vein is dark; the wing fringe is dark except for light spots at the apices of all the long veins but the second and sixth. Halteres with light stem and dark knob.

Length.—About 3 mm.

Habitat.—Camp Wilhelm, Tayabas, P. I.

Taken in November.

I am indebted to Dr. Malcolm Watson, Klang, Federated Malay States, for calling my attention to this species, the wing and palpal markings greatly resemble the dark form of *funesta*, and with the hand lens the light proboscis is not sufficiently marked to call attention to it, so I had laid it aside as being probably this form of a species so common on the Philippine Islands.

MYZOMYIA PARANGENSIS n. sp. Ludl.

♀. Head brown covered with white and dark brown forked scales, the white ones on the vertex and spreading laterad about one-half the width of the eyes, the brown fork scales on the rest of the head except a long tuft of slender white scales projecting forward between the eyes; antennae brown, verticels and pubescence white, a few

white scales on the proximal joints, basal joint brown with "frosty tomentum;" palpi fairly heavily scaled, the scales outstanding, brown except a small white tip and narrow white bands at the base of the penultimate and at the base on the antipenultimate, the apical joint is very short; proboscis brown, labella light; clypeus brown; eyes brown.

Thorax; prothoracic lobes dark brown with long yellow bristles; mesothorax a soft yellow, covered with "frosty tomentum" and sparsely by light yellow to white fine hair-like scales, more apparent in a median line of them, and long white scales projecting over the nape, but not confined to the very middle portion. A brown median line widening at the caudad margin, and continued still more broadly on the scutellum; scutellum much as mesonotum; pleura very dark brown with lines of white "frosty tomentum;" metanotum brown.

Abdomen dark brown, covered with golden brown hairs and a few long light spatulate scales on the apex of the eighth segment; the genitalia are also covered with long spatulate scales.

Legs: Coxæ and trochanters white; femora very markedly spotted or ringed in brown and white there being no marked predominance of either color, the spots rather large, the apices light, but sometimes only faintly so; tibiæ like femora, but the apices more distinctly white; the first tarsal joints are also markedly spotted and have an apical white band; the second tarsal joints are both apically and basally banded, more broadly in the fore legs, in the fore and mid legs usually with one intermediate spot; on the hind legs there are several intermediate spots, the third tarsals all have apical and basal light bands and at least one intermediate spot; on the hind legs the fourth tarsals have apical and basal bands, broader on the fore and mid legs, and the hind legs have the intermediate spot; the fifth tarsals are all basally light banded, and in some specimens at least a suggestion of an apical band. Ungues simple and equal. The bandings and spots on the hind tarsals, especially where there are only a few or one spot, divide the legs so they seem quite evenly marked brown and white.

Wings light yellowish, much mottled with dark brown. The costa has six brown spots and a mere dot, the last practically at the junction of the first longitudinal vein with the costa; proximad is a small white spot followed by a larger dark one extending on to the first longitudinal and the upper fork of the second long vein; then comes a light spot about three times as long as this second dark spot, followed by a small dark spot about half as long as the preceding dark spot and extending on to the first long vein; then a long light spot, followed by the third dark spot, which is the largest of all the dark spots, the distal third extending on the subcosta, the first long vein, on the stem of the second long vein, and on the third long vein, the last

two veins being less heavily marked than those cephalad of them; there is then on all these veins but the costa a light portion running under the remainder of the costal dark spot until the very proximal end, where the dark again extends as a tiny spot on the subcosta and first long vein. The fourth dark spot is not so long and extends on the subcosta and first long vein; the fifth dark spot is small and on the costa only, and the sixth spot is longer but also only on the costa. The wing field is much spotted. A small spot besides the "dot" spoken of on the upper fork of the second long vein near the base of the cell, and two on the lower fork, the one near the apex small, and there is one on the stem near the junction of the subcosta with the costa. The third long vein is mostly light, there being besides the dark spot connected with the large costal spot another dark spot just exterior to it and one near the apex of the vein; the fourth long vein has two spots on the stem and two on each fork; the fifth long vein is mostly light, but has one dark spot on the stem toward the base and three on its upper fork; the sixth long vein has three dark spots, one near the base, one about the middle, and one near the apex. The fringe is much mottled and is light at the junction of all the veins except the upper fork of the second long vein and at the junction of the sixth, and has, besides, light mid spots between the upper and lower forks of the fifth, between the fifth and the sixth, and beyond the sixth it is light save for two dark spots just interior to this vein. The apices of all the veins are light. Halteres with dark knobs and light stems.

Length.—About 7 mm.

Habitat.—Parang, Mindanao, P. I.

Taken.—October and November.

This is an unusually beautifully marked Anopheline, and probably lies nearest *ludlowii*, but the wing markings are quite different; the palpal bands are all narrow, and the legs very much more spotted than even the most distinctly marked of the *ludlowii* which I have ever seen.

Relation to malaria unknown.

Breeding places and habits entirely unknown. It is apparently a comparatively rare mosquito and has, so far, only been sent in from Parang.

Genus **CYCLOLEPPTERON** Theobald.

The characters of the genus are as follows: Palpi long in both sexes, about as long as the proboscis; in the ♂ the last two joints are swollen, forming a spatulate extremity; in the ♀ they are subulate. The venation is very similar to a typical *Anopheles*, but the wings have, in addition to typical *Anopheles* scales, patches of large jet-black scales, more or less inflated, and with their free end of a circular outline, these patches giving the wing a markedly spotted appearance. The typical lanceolate scales are comparatively few in number.

CYCLOLEPPTERON GRABHAMII Theob.

♂. Head dark brown, with black upright forked scales behind and at the sides, a patch of gray ones in the middle of the head, a few white ones projecting in front, and a long tuft of white hairs spreading outwards; eyes metallic coppery; proboscis long and thin, brown; palpi brown, bright brown at the swollen end, with prominent scales at the base; basal joint of antennæ dark brown.

Thorax silvery-gray, mottled with bright chestnut-brown, with two dark brown eye-like patches on each side toward the posterior half of the mesonotum, and a dark central line in front; a lateral tuft of dark, broadish scales on each side in front, and a patch of hair-like creamy ones in the middle, projecting over the neck; the whole mesonotum covered with scattered golden, curved, hair-like scales; scutellum grayish at the sides, brown in the center; metanotum yellowish-brown in some lights, with purplish tinges in others. When viewed with a hand lens the thorax appears bright brown and gray, frosted with gray hairs, the median dark line showing plainly, and also the four lateral spots.

The abdomen is absent, and the legs too damaged to make anything of, but the remaining wing is perfect, and presents the following peculiarities: The costa is dark, with a small pale patch about one-third of the length of the wing from the tip. The apex is fringed with yellow scales, broken by three small blackish patches, the upper part of the yellow fringe appearing as a yellow, apical, costal spot. The veins are sparsely bordered with pale spindle-shaped scales, and scattered over the veins, at wide intervals, are large, deep black scales unlike those of any other *Anopheles*. These scales are collected into a dense jet-black spot where the first long vein joins the auxiliary, the black spot of scales involving the second long vein as well. They are also collected rather thickly at the root of the fork cells, especially

of the first submarginal cell, and elsewhere. The first submarginal cell is about the same length as its stem; its base nearer the base of the wing than that of the second posterior cell. The latter is very short and broad, only a little more than half the length of its stem. Posterior cross vein about its own length distant from the mid cross vein. The third long vein is carried only a minute distance past the posterior cross vein.

Habitat.—Jamaica (Dr. Grabham) (24.11.1899).

Time of capture.—November.

Positive for malaria.

Breeding places in any stagnant water.

Genus **STETHOMYIA** Theob.

Allied to *Anopheles*. Head with a patch of *flat scales* in front on the middle line, and covered with numerous bristles and very thin upright forked scales almost like bristles; palpi in the ♀ long thin, four-jointed, the terminal joint slightly swollen near the apex. Thorax bristly but apparently nude; prothoracic lobes mammillated. Abdomen very pilose, hairs of two sizes, the smaller ones in rows. Wings unspotted, the veins clothed with long lancet-shaped scales. Legs long and thin with simple equal unguis in the ♀. Palpi of the male much swollen; claspers of the genitalia long; unguis of fore legs very unequal, the longer uniserrate; the mid and hind small, equal, and simple.

Differs from *Anopheles* in having some flat scales on the head and in the peculiar mammillated structure of the prothoracic lobes.

STETHOMYIA PALLIDA Ludl.

♀. Head, light testaceous, a few white flat lanceolate scales on the vertex, otherwise clothed with sparsely set slender hair-like curved brown scales, nearly as long as the very slender fork scales which occur on the occiput; two light-brown bristles project forward between the eyes, and a few around the eyes. The head shows no sign of having been denuded, and besides the slender hair-like scales is covered with a short fine tomentum or frostiness, such as is often seen on the thorax of *Anophelinae*. Antennæ brown, verticles brown, pubescence white, basal joint testaceous with frosty tomentum; palpi long and slender, covered ventrally with the short fine hairs of the frosty tomentum, dorsally with small flat brown scales, a couple of bristles or long hairs at the apex; proboscis light brown, covered with very thin flat scales and curved hair-like scales, a few bristles at the base, tip lighter; eyes dark brown; clypeus light, with frosty tomentum.

Thorax light testaceous, sparsely covered with hair-like brown curved scales, and frosty tomentum, prothoracic lobes a little darker, and with curved hair-like scales; scutellum like mesonotum; pleura light, with a few groups of hair-like curved brown scales; metanotum brown.

Abdomen apparently mottled brown and light, but this may be due to drying, and clothed with rather long brown hairs.

Legs unusually long and slender; coxæ and trochanters light, with a few hair-like curved brown scales. Remainder of the legs light,

covered with small, thin brown scales, which, in some lights, however, look much darker, with almost purple iridescence, in other lights almost fawn color. Ungues simple and equal.

Wing clear, brown scaled, with lanceolate scales; the first submarginal extremely long, nearly twice as long as the second posterior cell, and a little narrower, the stem about half the length of the cell, and a third shorter than that of the second posterior; cross veins close together, and all about the same length, the supernumerary about half its length interior to the mid, and the posterior about its own length interior to the mid. Halteres, stem light, knob dark.

Length.—3.5 mm. (legs more than 10 mm.).

Habitat.—Camp Stotsenburg, Angeles, Pampanga, Luzon Island.

Taken in September. "Caught in the woods."

Described from one very perfect specimen sent by Dr. Whitmore.

In spite of the fact that the prothoracic lobes are not mammillated, and indeed seem stalked, the other characteristics point so strongly to *Stethomyia* that I put this insect under that genus.

Relation to malaria unknown.

Breeding places and life history unknown.

Genus **PYRETOPHORUS** Blanchard.

Thorax with narrow curved scales, often rather elongated; abdomen with hair-like curved scales, practically hairs, the ♀ lamellæ only with scales; wings with small, short lanceolate or narrowish scales, much spotted as a rule, and palpi of the ♀ moderately scaled; legs banded, sometimes spotted. No flat scales on the head.

The larvæ frequent puddles and streams.

PYRETOPHORUS PITCHFORDII Power.

Wing clothed with narrow lanceolate scales; costa black at apex, pale at absolute base, with three large yellowish dots approaching the dark parts in length, and two basal dots; rest of veins mainly pale, but with several longish black marks, notably two on sixth long vein; fringe spotted at all long junctions. Legs dark but for apical femoral and tibial spots, and the tarsi minutely apically pale banded. Thorax dark with a broad band (stripe) of white bloom in the middle, and clothed with hair-like yellow scales behind, and creamy, narrow curved ones in front. Abdomen black, clothed both dorsally and ventrally with long golden hairs. The black scales near the fork of V on the wing are blunt ended.

♀. Head black, with few black scales behind and clavate white scales between the eyes, succeeded by white spindle-shaped scales and a rather scantily double white frontal tuft. Palpi moderately densely black-scaled, the outer fourth of the appendage white, with a narrow black band, and a smaller white band nearer the base; proboscis black, with yellow tip; antennæ with a long second joint clothed with white scales. Pleura mostly fuscous. Halteres with densely black-scaled knobs. A very slenderly built, dark looking mosquito.

Length.—About 4 mm.

Habitat.—Zululand, in brush country; elevation 1,500 feet. The valley is said to be notoriously malarious.

Philippine Islands, Camp Stotsenburg. This location also abounds in malarial fever. Reported from the Philippine Islands by Giles, to whom Maj. Whitmore had sent specimens.

Relation to malaria unknown.

Breeding places and life history unknown.

PYRETOPHORUS MIMIMUS Theob.

(Mono culicid, I, 186).

♀. Head black, clothed with black upright forked scales behind, and on the sides and over most of the occiput, a few gray and white creamy ones in front, also some curved white scales and a few white hairs projecting forward; proboscis deep brown; palpi deep testaceous clothed with black scales, a white ring toward the base (apical portion denuded), longer than the proboscis; antennæ deep brown, testaceous at the base, with dark hairs and gray pubescence.

Thorax slatey-gray in the middle, deep brown at the sides, the median gray area with rather large, round, brown dots (denuded); projecting over the head are some large white lanceolate scales; brown bristles over the roots of the wings; scutellum pale brown; metanotum deep brown; pleura brown.

Abdomen deep shiny blackish-brown with golden yellow hairs.

Legs testaceous-brown, covered with deep brown scales; no trace of banding or pale knee spots; ungues equal and simple; those of the forelegs curved, those of the mid nearly straight; femora rather paler than the rest of the legs, and those of the forelegs rather swollen.

Wings with black costa with three distinct nearly equal yellowish spots; apex yellow, forming a small apical spot; fringe brown with a yellow spot at the end of each vein, except the sixth; the middle of the three yellow costal spots is slightly the longest; all these spots are carried on to the first long vein; the apical spot also just touches the tip of the first long vein and the tip of the upper branch of the first fork cell; second long vein and the fork entirely dark scaled; the third yellow in the middle, dark at the base and apex; the fourth mostly dark scaled, the fifth and sixth mostly dark scaled, a trace of yellow on the upper branch of the fifth; first submarginal cell considerably longer and slightly narrower than the second posterior cell, its base much nearer the base of the wing than that of the latter, its stem much less than half the length of the cell; stem of the second posterior cell considerably longer than the cell and than the stem of the submarginal cell; the subcostal joins the costal in the median yellow spot, some way from the base of the submarginal cell; supernumerary cross vein nearly its own length in front of the mid cross vein, which is longer than the supernumerary, posterior cross vein a little longer than the mid, more than its own length distant from it; third long vein carried very prominently into the basal cell. Halteres with gray stem and large cup-shaped black knob.

Length.—3 mm.

Habitat.—Hongkong (Rees); Camp Stotsenburg, Pampanga, P. I. (Whitmore).

Relation to malaria unknown.

Breeding places and life history entirely unknown.

The description suggests *funesta*, but I have not seen the specimen which was, I think, determined by Giles.

PYRETOPHORUS (♀) FREERÆ Banks (1906).

Small, dark gray, with light gray, lanceolate thoracic scales and golden hair-like abdominal scales; fore and mid legs with banded tarsi; *posterior tarsi snow white*; palpi dark brown, white tipped and narrowly white banded before apex; a few white hairs at middle of palpi; frontal tuft white and nearly as long as head; antennæ pale brown with white hairs.

Described from a single ♀ with no mid legs.

Habitat.—Manila, P. I. (Banks).

Time of capture.—October 23, 1906.

Type in the Bureau of Science, Manila, P. I. No. 5975.

Relation to malaria unknown.

Breeding place and life history entirely unknown.

The description is entirely inadequate, and it would be impossible to determine a specimen by it, unless the type were available. It suggests a *Nyssorhynchus* and might be one of two or three.

Genus **MYZORHYNCHUS** Theob.

Characters.—Thorax with hair-like scales; prothoracic lobes with ragged scales; the abdomen with ventral, and a few apical scales, and a ventral apical tuft; there are no lateral scale tufts to the segments; wing scales broadly lanceolate or moderately lanceolate, sometimes short and broad; palpi densely scaled in the ♂, and also the proboscis. Wild species, breeding in swampy ground.

MYZORHYNCHUS SINENSIS Wiedemann.

(Theob. Mon. Cul., vol. 1, 137.)

♂. Head blackish with white scales in front, black tipped with gray behind; antennæ brown with narrow pale basal bands at joints, basal joint testaceous, with pale scales, which also occur on the next few joints; palpi densely scaled with long brown to black scales, with a white scaled apex and two white bands at the apex of third and fourth joints; proboscis black; clypeus brown.

Thorax slatey-gray with purplish brown longitudinal stripes, with numerous small dark specks, adorned more or less with narrow pale golden scales; scutellum dull pale ochraceous or gray with the center deep purplish brown; metanotum deep, clear purplish brown to almost black; pleura brown and silvery gray.

Abdomen with brownish black, and testaceous ground color; in some specimens there is a narrow apical pale border to the segments, seen in certain lights; posterior segments mainly testaceous; all the segments are covered and edged with long golden hairs, the end ones particularly so.

Legs testaceous when denuded; covered with brown scales above, dark yellowish below; tibiæ and tarsi, except the last, with apical pale bands (in some, both sides of the joints are involved); in the hind legs the metatarsus is longer than the tibia, and the first tarsal joint about half the length of the metatarsus; in the fore and mid legs the last two tarsal joints show little or no banding; ungues equal and simple.

Wings with the costa covered with dark brown to black scales, with two rather large prominent yellowish white spots which extend on to the first long vein, and upper branch of first fork cell; one spot is near the apex, the second where the subcostal vein joins the costa; the veins are covered with light brown, dark brown, and creamy scales, the dark brown forming patches on the bases of the two fork cells where the veins join the wing border, at the base of the third long vein, and the base of the second long vein; three more or less distinct

patches are present on the upper branch of the fifth one near its base, and a few on the apical part of its lower branch; two patches on the sixth, while the subcostal and first long vein have all brown scales except where the yellow costal spots are carried over them; fringe yellow at the apex, a small black patch separating it from the costal spot, a pale patch where the lower half of the fifth vein joins the border, all the rest dusky violet black, except the "border scales," which are pale yellow in reflected light; first submarginal cell and second posterior cell of nearly equal length; base of the latter just a little nearer the base of the wing than that of the former; stem of the first submarginal about two-thirds the length of the cell; stem of second posterior equal to that of the former cell; posterior cross vein not quite half its length distant from the mid cross vein; mid cross vein a little nearer the base of the wing than the supernumerary; the posterior cross vein slightly the longest of the three; base of the first submarginal cell some distance from the junction of the subcostal with the costal; halteres with pale stem and dark knob.

Length.—5 mm.; probos., 2.5 m.

Taken at Formosa, China; Philippine Islands, rather rarely, however.

Differs from *vanus* in having (i) a pale spot where the upper branch of the fifth long vein joins the margin (ii) it is larger; (iii) and in position of cross veins; the latter a doubtful character, however.

Positive to malaria.

Little is known as to breeding places and life history, but James¹ believes the whole *sinensis* group breeds in dark shady pools.

Positive to *filaria nocturna*.

MYZORHYNCHUS VANUS, Van der Wulp.

(Mono. Cu., i, 142; iii, 90.)

♂. Head black, with yellowish white upright scales in front, and black ones behind tipped with gray; deep black ones at the sides, a tuft of long white hairs projecting between the eyes; antennæ dark brown, basal joint testaceous, almost black, on the inside with pale gray scales; palpi covered with long brown scales, with the apex white, two other prominent white rings, and some white scales toward the base, sometimes four-ringed, nearly as long as the proboscis; proboscis densely covered with black scales, apex testaceous.

Thorax brown, dusted with frosty gray, with a narrow median line and broader lateral ones of dull violet hue, and also two long oval, dark, lateral eye-like spots, the whole covered with minute dark specks with scattered long, pale hair-like scales, white in front, golden on the dorsum and behind; pleura dark brown with some

¹ James, S. P., and Liston, W. G. *Anopheles Mosquitoes of India*, 1904, p. 81.

gray markings; metanotum dark brown; scutellum pale ochraceous gray, dark brown in the middle.

Abdomen shiny black with a dull violet tinge in some lights with long golden brown hairs.

Legs dark yellowish-brown, with dark brown scales, with a dull bronzy yellow reflection in certain lights; apices of the hind metatarsi and first three tarsal joints narrowly banded yellow, last joint dark brown; in the fore and mid legs the first two tarsi only are banded; hind metatarsi longer than the hind tibiae, first tarsal joint not one-half the length of the metatarsus; ungues equal and simple.

Wings with the costa covered with black scales broken by two small yellow spots, the apical one distinct and extending on to the first long vein and the upper half of the fork of the second long vein; the second spot where the subcostal joins the costa very indistinct, more or less extending on the first long vein and the pale area extending some distance basally under the dark costa, rest of wing



FIG. 23. Wing of *M. Vanus*, Van der Wulp.

markings as in *M. sinensis*, except that there is no pale patch on the fringe where the lower branch of the fifth vein joins the border; apical fringe yellow, but the black spot between it and the apical costal spot larger; cross veins separate, the posterior longer than the mid, distant from it more than its own length, and the supernumerary distant from the mid about two-thirds of its own length; base of the first submarginal cell a little nearer the base of the wing than the base of the second posterior cell. Halteres pale yellowish-brown with a fuscous knob.

Length.—4.5 mm.

♂. Palpi densely covered with black and gray scales at the base, less so on the remainder, apex with black and gray scales, truncated, antepenultimate joint deep black with a narrow border of white scales; penultimate joint with thin white border and hair tufts brown; antennae banded, with brown verticils. Ungues of forelegs unequal, the larger one with two large teeth and a trace of a third at the base;

mid and hind equal, and simple, the hind smaller than the mid and nearly straight.

Length.—3.8–4.5 mm.

Habitat.—Straits Settlements, Madras, Central Provinces, and Philippine Islands.

Relation to malaria unknown.

Belongs to the general *sinensis* group, and according to James this whole group breeds in dark shady pools.

MYZORHYNCHUS BARBIROSTRIS, Van der Wulp.

Thorax deep grayish, with slaty reflections, dark longitudinal lines and minute black specks, with long scattered golden hair-like scales. Abdomen nearly black. Legs dark brown, with apical bands to the tibiæ and tarsi. Costa black, with two small yellow spots on the apical half; apical fringe black, except between the second and third veins; scales more robust than in *M. sinensis*.

♀. Head black, covered with black upright broad forked scales behind, gray at the tips, and with creamy white ones in front, a median bare space and a few projecting white and black bristles in front; antennæ black, with pale bands, basal joints black; palpi densely covered with deep black scales, making them nearly as wide as the head, as long as the proboscis, all traces of the joints hidden by the dense scales.

Thorax deep grayish, with slaty reflections, deeper colored thin longitudinal lines, and numerous dark specks, covered with scattered long golden hair-like scales; pleura brown and ashy gray, with a few white scales; scutellum deep purplish-brown in the middle, paler at the sides, with very pale golden curved scales and long dark brown bristles; metanotum deep brown.

Abdomen much as in *M. sinensis*. Legs testaceous, densely covered with dark brown scales, apex of the tibiæ with a yellow band, also the tarsal joints, except the last; ungues equal and simple.

Wings densely covered with dark scales and a few pale ones; costa black-scaled, a small pale yellow apical spot and another still smaller and paler where the subcostal joins the costa; the former just includes the scales at the tip of the first long vein and the tip of the upper branch of the second long vein; the second spot only on the costal vein; first submarginal cell longer and narrower than the second posterior cell, its base just a little nearer the apex of the wing, its stem equal to about two-thirds of its length, shorter than the stem of the second posterior cell, which is a little longer than the cell; base of the first fork cell not near the second costal spot; mid cross vein a short distance from the supernumerary; posterior cross vein more than its own length distant from the mid; fringe black, with a pale

spot at the tip of the third long vein and slightly paler where the lower branch of the fifth joins the edge; scales of the wing more robust than in *M. sinensis*, those of the upper branch of the fifth being comparatively short and broad with an acuminate tip. Halteres jet black, slightly pale at the base.

Length.—5 mm.

Habitat.—Selangor (Wray); Upper Burma (Watson) (4.94); Old Calabar (Annett); Philippine Islands (Ludlow).

Time of capture.—August in Upper Burma (Watson); April in Old Calabar (Annett).

James reports it experimentally positive to malaria, but not found infected in nature, and Christopher¹ says that because of its sylvan habits, it is believed not to “play much part in the transmission of malaria,” though it may act as a carrier in the case of forest camps or even in the case of convicts working during the day in the forest. Christopher and Watson both found it flying in the day time and Christopher reports it attacking freely during the day.

Watson and Christopher report *barbirostris* breeding in swamps, in pools at the edge of forests, in the jungles, on the hill range, and James reports it breeding in dark pools with much vegetation, lily ponds, tanks overgrown with green weed. Dr. Watson found them so plentiful at one time that he and Dr. Leicester and an attendant “caught something like 200 anophelines in a quarter of an hour” (p. 19)² and that other mosquitoes were even more abundant.

¹ Malaria in the Andamans (Christopher).

² Prevention of malaria in Federated Malay States (Watson).

MYZORHYNCHUS PSEUDOBARBIROSTRIS Ludlow.

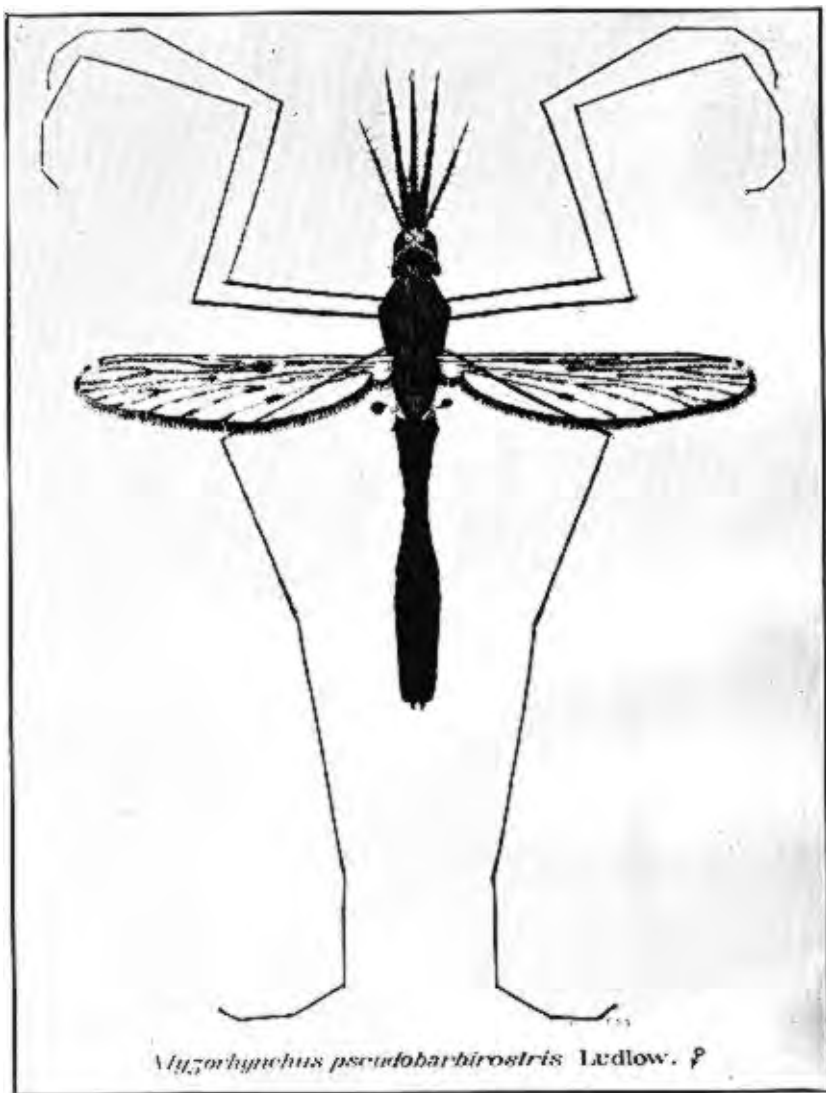
♀. Head very dark brown, with some pale scales on top, spreading in front toward the sides, and partly around the eyes, tuft in front white with a few dark hairs, and dark hairs behind the eyes, otherwise covered with rather broad not deeply forked scales with fimbriated tops, the tips gray; narrow median space bare. Antennæ a lighter brown, minute white apical hands on the joints, first joint brown; verticels brown, pubescence white. Palpi very heavily scaled with dark brown (almost black) scales, many of which are ochraceous tipped, so that the effect is "rusty"; joints obscure but can be seen by breaks in the scales; as long as the proboscis; last joint with brown hairs. Proboscis also heavily dark scaled, some ochraceous tipped; tip is lighter but still brown. Eyes dark brown, narrow white rim part of the way around.

Thorax dark brown with gray reflections, and narrow curved (almost hairlike) golden scales, arranged in faint, i. e., indefinite lines, which in some lights seem to converge so as to form a V from the cephalic edge the whole length of the thorax, the point caudad; pleura brown with white markings; scutellum brown at center, paler laterad, with slender golden curved scales (such as are on the thorax) and golden bristles; metanotum brown.

Abdomen dark brown, slight grayish reflections, golden hairs; on the ventral side are a few scattered white scales and near the caudal end a bunch of rather long brown scales.

Legs.—Coxæ and trochanters all dark brown, white-tipped; femora and tibiæ all dark brown, well sprinkled with white scales, the rest of the legs a little lighter brown, and in some lights giving almost "fawn-colored" reflections; all the joints of the legs and feet are white-tipped, except the last tarsal joints, and on the mid legs that is a little lighter, giving almost "clay-colored" reflections. Ungues simple and brown.

Wings dark, with two small yellow spots on costa, one at the apex of the wing and extending on the apices of the first longitudinal and anterior fork of second longitudinal, with light spots on the fringe at apices of first longitudinal and anterior fork of second longitudinal and an included dark spot at apex of marginal cell, giving the appearance of an incomplete ring (c); the other, much smaller, on the costa at junction of the subcosta. The costal and basal portions of the wing are dark-scaled with a few white scales on the costa, subcosta, first and second longitudinal, but the third longitudinal



is mostly white-scaled, and on this appear a few of the round-ended scales. The fourth longitudinal is largely dark-scaled with a few of the longer scales, but the scales are mostly of the roundish sort which are either black or white; there are dark spots at the apices of each fork and light fringe at the apex of the anterior fork. The fifth longitudinal has almost exclusively the rounder scales, and is mostly white, both as to stem and forks; dark spots at the apices of each fork, and the stem has a dark base, as have all the veins except the sixth, which is light-scaled, save two heavy dark spots, one at the apex and one about the middle of the vein. The sixth has entirely the roundish-ended scales in both black and white. The fringe is dark except for the three small places indicated, i. e., at the apices of first longitudinal, anterior fork of second, and anterior fork of fourth longitudinal. Most of the veins, even where light, have a sprinkling of the dark among the median scales, but the larger part of the dark scales on these veins are lateral scales and lie close under the median scales, so that the wing looks much darker from the under (ventral) view, and in all the veins caudad of the third the lateral as well as the median scales are almost entirely of the "round-ended" sort. The wing has, however, as a whole a dark rather than light appearance, probably due to the very heavy scaling of the first two or three veins, which are mostly dark-scaled. The first submarginal cell is a little longer and narrower than the second posterior, the base of the former nearly on a line with the base of the latter, but not near the junction of the costa and subcosta; the stem of the former is about two-thirds the length of the cell, and shorter than that of the second posterior, which is longer than the cell. The cross-veins are close together, the mid-vein much the longest, meeting the supernumerary at nearly a right angle (toward the apex of the wing), and the posterior cross-vein is not half its length from the mid-vein and stands at almost the same angle in the reverse direction. The halteres have black knobs, stem and base are light.

Length.—5 mm. (with proboscis 7 mm.).

Habitat.—Philippine Islands.

Relation to malaria unknown.

Breeding places and life history entirely unknown.

Genus **NYSSORHYNCHUS** Blanchard.

Thorax with narrow curved and spindle-shaped scales; abdomen with small flat or narrow dorsal scales, especially on the apical segments; ventral tufts of long scales; wing scales bluntly lanceolate; palpi densely scaled; leg banded mottled or spotted.

NYSSORHYNCHUS FULIGINOSUS Giles.

(Gnats or mosquitoes, 1st ed., p. 160.)

"Wing spotted; costa black, except at apex and base, and interrupted by three fairly large yellowish spots, involving the aux. (subcosta) and I (first long vein). There are also two small black dots on the white basal portion of the costa only, and numerous black dots on the long veins. Last three hind tarsal joints and apex of second wholly white; first, second, and third tarsal joints of fore and mid legs

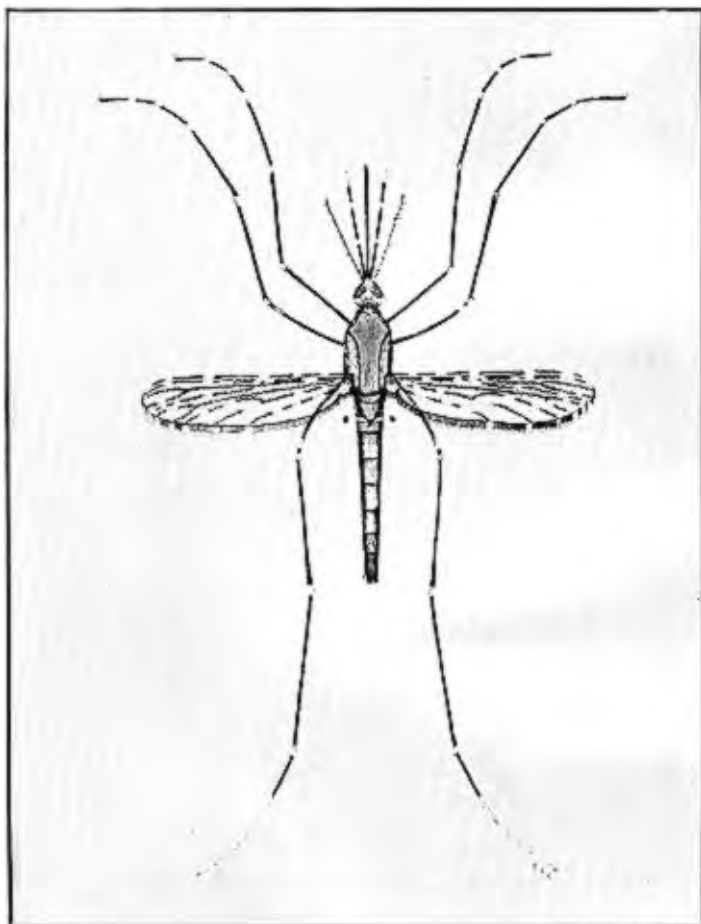


FIG. 24. Wing of *Nyssorhynchus fuliginosus* Giles.

apically tawny banded. Thorax black, with whitish yellow scales. Abdomen black, with some (mostly basal) white scales, and numerous golden hairs on the segments."

Head black, with a distinct bifid white tuft; palpi of ♂ black with white tuft (apex) and two narrow but distinct white bands on the articulations next to it; the coxæ have numerous silvery tufts; the large black costal spot next but one to base extends to corresponding portion of I but is divided into three minute interruptions. The wing behind I is mainly pale ferruginous, but there are numerous black portions on the long veins, and the internal fringe shows distinct tawny interruptions opposite each longitudinal junction. Scutellum deep slaty black, with creamy white scales, which form two lateral tufts, small black bristles on the mid lobe, long ones at the sides; pleura deep slaty brown; metanotum deep brown to black.

This is Ross's "small dapple wing."



Nyssorhynchus fuliginosus Giles.

Length.—3.5–4.2 mm.

Habitat.—Madras and Punjab, India. Generally in the Philippine Islands.

Positive to malaria.

Breeding places. In India the larvæ are found in tanks, large natural ponds with grass and weeds at the edges, in canals amongst the weeds, and in shady weed-grown pools under trees in clear water.

NYSSORRHYNCHUS PHILIPPINENSIS Ludlow.

(*A. philippinensis* Ludl., Journ. N. Y. Ento., September, 1902.)

♂ Head very dark brown, with white and creamy (yellowish) scales scattered on top, and more thickly toward the front, long white tuft in front, a few yellowish scales on the sides, and very dark forked scales with fimbriated tops on the occiput; antennæ golden brown some white scales and some brown at the base with lighter tips, verticels white, pubescence white, first joint basally brown but white at apex; eyes dark brown or black, with very narrow white rim; palpi golden brown, some scales apparently darker tipped, the last joint white and a narrow white band at apex of each of the three preceding joints, a few white scales at the base; proboscis brown, not so dark as the head but darker than the antennæ; white or yellowish tip.

Thorax very dark brown (both it and the head are almost black), with scattered white, flat and yellowish curved scales, no design apparent, cephalad the white scales are much longer; scutellum dark brown in the middle and at each end with a lighter spot between on

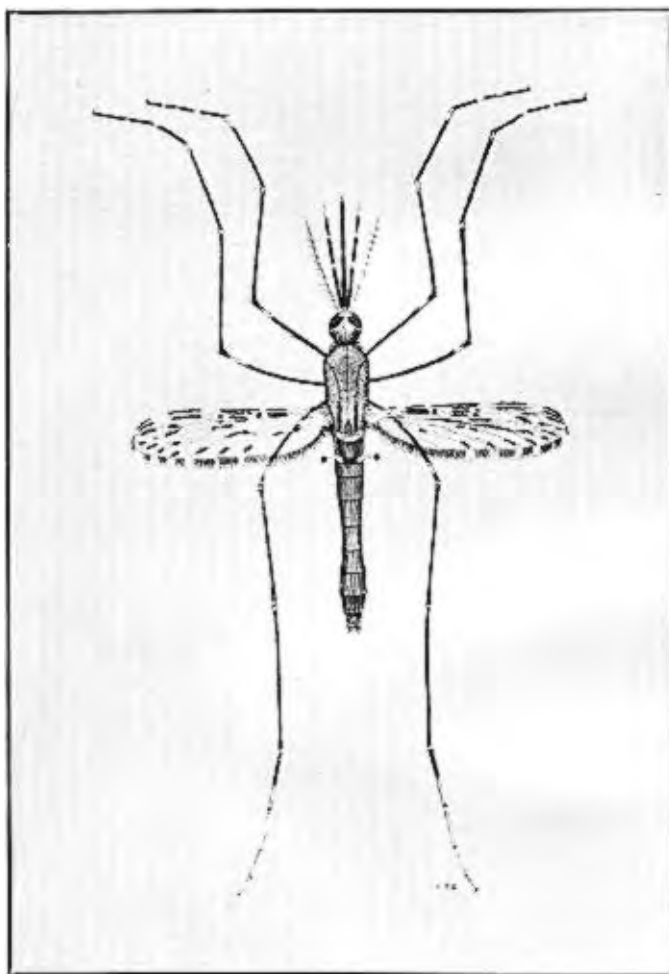


FIG. 25. Wing of *N. philippinensis* Ludl.

which are a few white scales; metanotum dark brown; pleura dark brown with white markings; when denuded thorax has ashy-gray reflections with dark brown median line.

Abdomen dorsally is ashy-gray with golden-brown hairs, a narrow brown apical band on each segment, much broader on the last two segments so that they are nearly brown instead of gray.

Legs.—Coxæ brown, all white-tipped; femora dark, i. e., brown-scaled dorsally, and yellowish on the ventral side, tibiæ same but a very small apical white spot on fore and mid legs; first, second, and third tarsal joints on the fore legs have heavy apical white bands; mid legs have faint white bands in the same positions, that on the first tarsal much the heaviest, but still not by any means so broad as on the fore legs; hind legs dorsally brown, and yellowish ventrally, much as in the other legs, but the apical half of the second tarsal and all the following joints pure white, ungues on all legs simple and equal.



Nyssorhynchus philippinensis Ludl.

Wings cream-colored spotted with brown, reminding one of *A. Jamesii* Theo. Two small and four large brown spots on costa, the distal extending back through anterior fork of second longitudinal, the next somewhat larger, through first longitudinal; the third and largest of all extends as a long spot on the costa and subcosta and three small ones on the first longitudinal, so arranged as to resemble an overturned E (\sqcap); the middle of these is the largest and connects with one on the second longitudinal; the fourth spot (counting from the apex of the wing) includes the subcosta and the first longitudinal, and even the two small ones include the subcosta, making all these costal spots very distinct. The apex of the costa is, however, light. There are two dark spots on anterior fork of second longitudinal, and one on the posterior fork; two small spots at the base of the third longitudinal; one on the anterior fork of the fourth longitudinal, a small one near the apex of the posterior fork, the stem is dark to posterior cross vein, and after a small white spot, about one-half the way to the base of the vein; anterior fork of fifth has three dark spots, and there is one on the posterior near the apex, also on the stem of fifth near base of wing; there are three dark spots on the sixth longitudinal, one at the apex, one near the middle, and one near the base. A large part of the second and fourth are therefore dark, while the fifth has a large part cream colored and still a larger proportion of the third is light. The fringe is mottled, cream and brown, nearly equally, to the sixth longitudinal, after which it is dark. Dark spots occur in the fringe at the apex of the anterior fork of the second longitudinal and at apices of the first posterior, second posterior, third posterior, anal, auxiliary, and spurious cells (Theobald's naming) with light spots at the apices of each intervening vein. The first submarginal cell is a little longer than the second posterior, the base of the former being a little nearer the base of the wing. The posterior cross vein is about one and one-half times its length nearer the base of the wing than the mid cross vein, and the supernumerary vein a little nearer the apex of the wing than the latter.

Length.—(Including proboscis) 5 mm.

Habitat.—San Jose, Abra, Luzon, P. I.

Caught September 1, 1901. Since then taken in many localities in the Philippine Islands.

This mosquito is related to *A. Jamesii* Theo., but differs in so many points—antennæ, palpi, wings, legs—that although the differences in antennæ and wings are not great, those of the palpi and legs are so distinctive I decided, after some hesitation, to keep it a distinct species. Specimens sent in during 11 years have always run true and there seems to be no reasonable doubt as to the validity of the species.

Relation to malaria unknown.

Breeding places and life history unknown.

NYSSORHYNCHUS KOCHI Dönitz.

(*Nyssorhynchus flava* Ludl.)

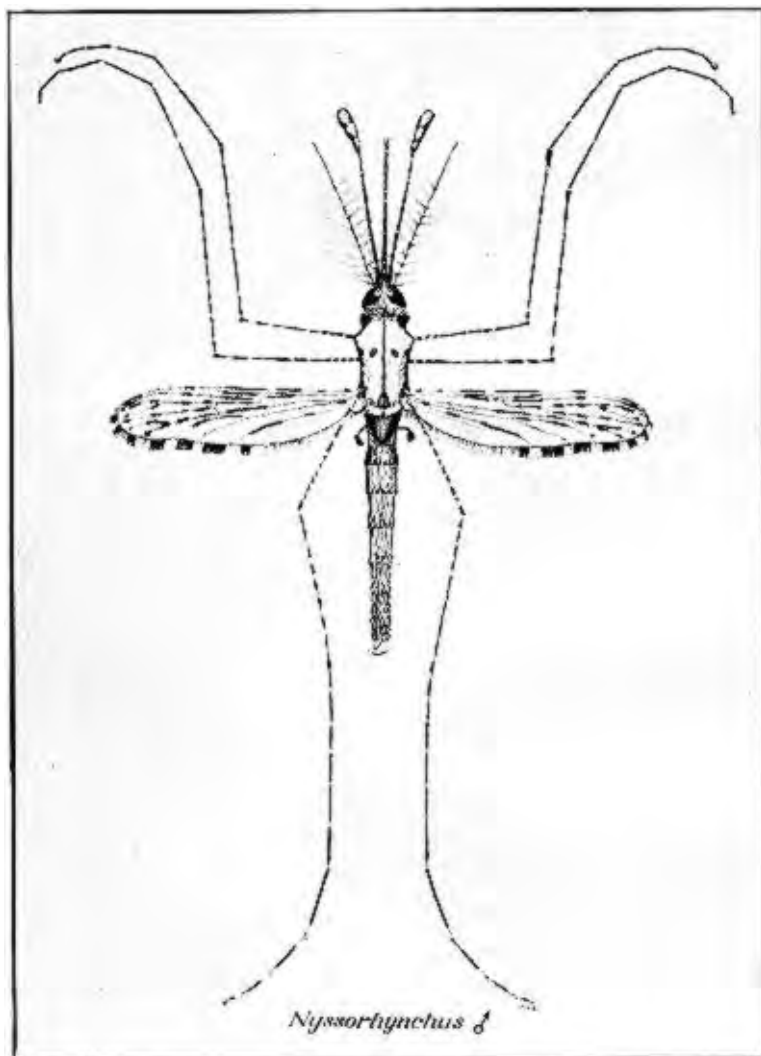
(*Cellia flava* Ludl.)

♂. Head dark, covered mostly with light yellow or white forked scales, a few brown ones laterad and ventrad, a heavy bunch of very long, slender white curved scales projecting forward between the eyes; some brown bristles around the eyes; antennæ almost white, a minute brown band at the base of each row of verticels; verticels and pubescence white; basal joint testaceous; palpi almost white, the distal half covered with yellow and white scales, i. e., the apex with a broad band of white followed by a broad yellow band, a minute brown basal band on the ultimate and penultimate joints; the antepenultimate is distally white, then a broad yellow band occupying most of the joint, a narrow basal brown band, and the remainder of the palpi heavily scaled by brown with some intermixture of yellow scales. Proboscis light, base heavily brown scaled, then a mottled portion extending to the distal third, which is covered with light yellow scales, except a narrow brown band at its extremity, labella light orange; clypeus testaceous; eyes brown.

Thorax: Prothoracic lobes testaceous, covered with light and brown flat spatulate scales, mammillated; mesonotum light and delicate, with two small submedian or laterad brown spots (not scaled) about one-third the length of the mesonotum from the head, sometimes another pair just cephalo-laterad to these, a suggestion of a brown median line, the whole (except the spots) covered with slender hair-like curved scales, a few small flat curved or spatulate scales scattered throughout, more noticeable laterad, especially cephalad of the wing joint, and at the nape growing into a tuft of long flat curved spatulate scales, a dark median spot cephalad of the scutellum; scutellum dark in the middle, sides light, brown bristles; pleura light, with some brown lines; metanotum light, with median brown stripe.

Abdomen light or dirty gray, sparsely covered with long, flat, spatulate white or yellow scales and white or light yellow bristles, heavy submedian ventral tufts of long brown broadly truncate scales on most (six) of the segments, the last segment more heavily white scaled.

Legs: Coxæ light, sparsely covered with long spatulate white scales and white bristles; trochanters light, mostly brown scaled; femora of the forelegs somewhat thickened at the base; in all the legs covered with irregular bands or spots of brown and white and have



Nyssorhynchus kochii Dön (*N. flavii* Ludl.)

a very narrow apical band; tibiae mottled in the same way, first tarsal joint also mottled, and has narrow apical bands more marked on the hind legs; remainder of tarsal joints on fore and mid legs more or less distinctly mottled and having narrow apical light bands; on the hind legs the second tarsal has a broad apical white band, the third has broad apical and basal white bands, the fourth and fifth are marked in the same way. Ungues simple and equal.

Wings light, and mostly light scaled; on the costa are two tiny basal dark spots, four large brown spots, and a tiny brown spot between the two more proximal larger spots, all of which extend on the first long vein, and an analogous intermediate spot on the first long vein. Wing field somewhat spotted, but mostly light scaled; a dark spot on each fork of the second long vein; third long vein light except small spots at the apex and near its base; two small spots on the forks of the fourth, and a couple on the stem; three small spots on the upper fork of the fifth, one on the lower fork, stem light except that close to the base is a small dark spot; the sixth has three small spots, and the wing fringe is spotted between the junctions of every vein.

Length.—3.5 mm.; 5 mm. with proboscis.

♂. Much as the female. On the antennae the bands at the bases of the verticils are more yellow; the palpi are not so distinctly marked, there being a narrow brown band in the middle of the "club," a white band followed by yellow at the apex of the penultimate, with a brown spot on one side and a very narrow basal brown band; the antepenultimate has the light and dark bands rather irregularly placed and a tiny narrow white band at the base (in one specimen this is nude). The leg markings are perhaps more brilliant; fore unguis markedly unequal, the larger with a long tooth.

Habitat.—Camp Wilhelm, Tayabas, P. I.

Taken September, 1907.

Described from four specimens collected by the surgeon on duty at this post. It is a very unusual looking Anopheline, and its coloring is very attractive.

Relation to malaria unknown.

Dr. Watson writes me that Edwards thinks this may be *kochi* Dön. in which case it is also taken in the Straits Settlements, Sumatra, Java, and the Federated Malay States. Dr. Watson¹ found *kochi* to be a "flat land" mosquito, taken in houses, and breeding in "mud holes," i. e., hoof marks, wagon ruts, etc.; in shallow water supplied by rain and liable to dry up; in swamps, in marshy ground fed by streams, and he writes me there is plenty of epidemiological evidence to show that this species is not connected with the transmission of malaria.

¹ Prevention of malaria in the Federated Malay States, p. 18.

Genus **CELLIA** Theobald.

Thorax with flat spindle-shaped scales; abdomen covered with irregular scales and dense lateral tufts; palpi of female densely scaly; wing scales large, bluntly lanceolate; wings densely scaled.

CELLIA ARGYROTARSIS Rob. Desvoidy (1828).

(*A. albitarsis* Arribalzaga (1891).)

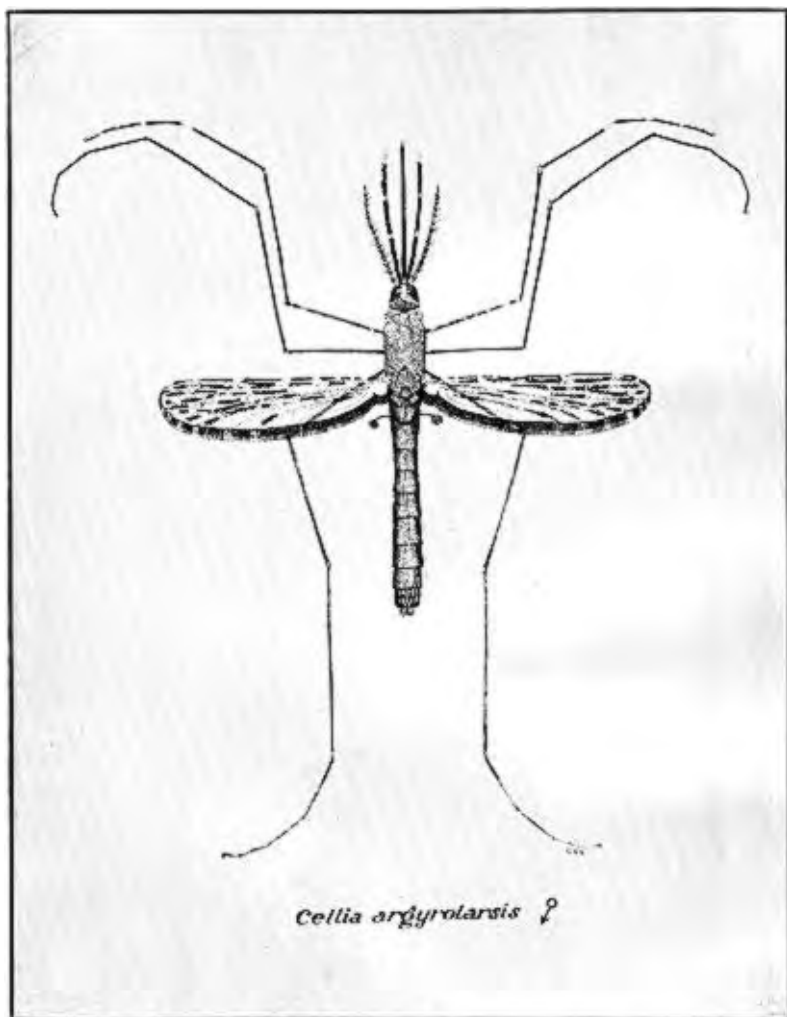
Thorax with mesonotum bluish gray, with three more or less longitudinal lines and with pale scales over the mesonotum, and sometimes traces of two dark lateral spots. Abdomen dark dusky-brown, with a few creamy scales. Legs covered with dark scales, with some of the tarsi apically white banded; last three joints of hind legs pure white, and also apex of first; costa dark, with two distinct and several smaller pale spots.

♀. Head black, with white upright spatulate scales in front, black behind and at the sides, a tuft of white hairs projecting forward between the eyes. Eyes black; antennæ dark, with pale silky pubescence and brown hairs; basal joint dark, a few patches of white scales on the first few basal joints; palpi covered with long black scales, especially along toward the base; apex pure white, and there are also two narrow white rings on the apical ends of the joints; ventrally the penultimate joint has a number of yellowish-white scales, which sometimes seem to form almost a ring; proboscis clothed with short dark scales.

Thorax with a bluish-gray sheen, with three more or less distinct longitudinal lines, the middle one most distinct and of a purplish hue, with pale scales scattered over the mesonotum; scutellum dark toward the middle; metanotum deep brown; pleura dark, with here and there frosty tomentum (there are traces of two dark lateral spots on the mesonotum, which are clearly seen in the St. Lucia specimens).

Abdomen dusky purplish brown, clothed with creamy yellow scales, especially in the middle region of the segments; the segments have lateral tufts of gray scales on the posterior borders, projecting from the sides; hairs long, deep bright brown; viewed with a pocket lens the abdomen is almost black in ground color; in other specimens dull yellowish reflections may be seen.

Legs yellowish, covered with dark brown scales; first two tarsi of the fore legs apically white, last two joints dark brown, fore metatarsi



also with small pale apical bands; mid metatarsi and first two tarsal joints with minute apical yellow bands, last two indistinctly banded; in the hind legs the last three joints are pure snow white, and also the apex of the first; unguis very dark.

Wings with the costa dark, with four distinct and several smaller white patches; there are also numerous patches of dark scales, which vary to some extent over the wing areas; in the ♀, from which this description is taken, the fourth long vein is covered with pale dusky scales, whilst in a ♀ from St. Lucia it is creamy white; halteres with pale stem and fuscous knob.

Length.—4 to 5 mm.

♂. Palpi dark brown, with scattered white scales, especially on the last swollen joints; hair tuft pale; there is a pale ring at the apex of the apical and base of the penultimate joint; antennæ brown with brown plumes; proboscis brown and narrow. The white scales on the head extend nearly over the neck; scales on the thorax white; the larger unguis of the fore feet biserrated.

Length.—4 to 5 mm.

Habitat.—St. Lucia (St. George Gray, November 25); Rio de Janeiro (Dr. Lutz) (July 4, 1899); Jamaica (Dr. Grabham); British Guiana (Rowland); Antigua (Forrest); Grenada (Broadway) (Feb. 2, 1900). Cuba, Canal Zone, etc.

Time of capture.—Jamaica, November to March; July, in British Guiana.

Positive to malaria.

Positive to *Filaria nocturna*.

Breeding places chiefly in fresh pools of rain water, along edges of sugar-cane fields, sides of roads; practically in nonpermanent pools. The breeding places contain surface food. They do not breed, or rarely, in pools unprotected by rocks, bushes, or other vegetation, and that are continually wind swept; never in pools in which tall reeds and bamboos exclude the light; not in a continuous current, nor in close association with their enemies, nor in any situation easily reached by them.¹

The larvæ vary greatly, being light brown in a light-colored opaque pool; in a dark pool nearly black, while among beneficent algæ they may present a beautiful transparent green-tinted appearance.

¹ Nicholls, L. Annual Report. St. Lucia, W. I., as quoted in Bull. Ento. Res., Vol. I, p. 213. Also see Nicholls, L. Some observations on the Bionomics and Breeding Places of *Anopheles* in Santa Lucia, B. W. I., Bull. Ento. Res. Vol. III, pp. 251-265.

CELLIA ALBIMANA Wiedemann.

(*Cellia albipes* Theob.)

This species resembles *Argyrotarsis*, but differs in the following points.

The last tarsal joint in the hind legs has a very distinct and persistent deep black basal band. The thorax is rather browner in some specimens, and there are only two white bands to the ♀ palpi. The fore legs have dark scaled femora, pale beneath, with a small white knee spot, the tibiæ dusky scaled and also the metatarsus above, pale below, apex white; the first two tarsi have yellow apical bands, the third dark, and the last clay colored; mid legs with a white spot near the apex of the femora; mid tarsi not definitely banded, but with a faint pale band sometimes at the apex of the metatarsus; the hind legs are dark brown, with the second, third, and apex of the first tarsal joints pure white, the last joint white, with a distinct black basal band; ungues as in the type. Wings much as in the type, but the pale scales are more yellow in color.

Length.—♂ 3.5 to 4.5 mm.; ♀ 4 to 4.5 mm.

Habitat.—Jamaica (Grabham) ♂ 7.12.1899, and 8.2.1900); British Guiana (Rowland); Rio de Janeiro (Lutz); Antigua (Forrest); India (Giles); Canal Zone, etc.

Time of capture.—November to March in Jamaica; July, British Guiana.

Positive to malaria (æstivo-autumnal and tertian and for *Filaria bancroftii*).

Dr. Low finds the breeding places very varied, ranging from hoof marks, small water holes, ditches, trenches, swamps, in fresh water, in shallow water, to marshes, and, when protected by certain algæ, and in brackish water, even in lagoons shut off from the sea by a sand bank only 10 yards wide when the only apparent vegetation in the water was some old seaweed.

Dr. Nicholls reports the breeding places to be the same as those of *argyrotarsis*.

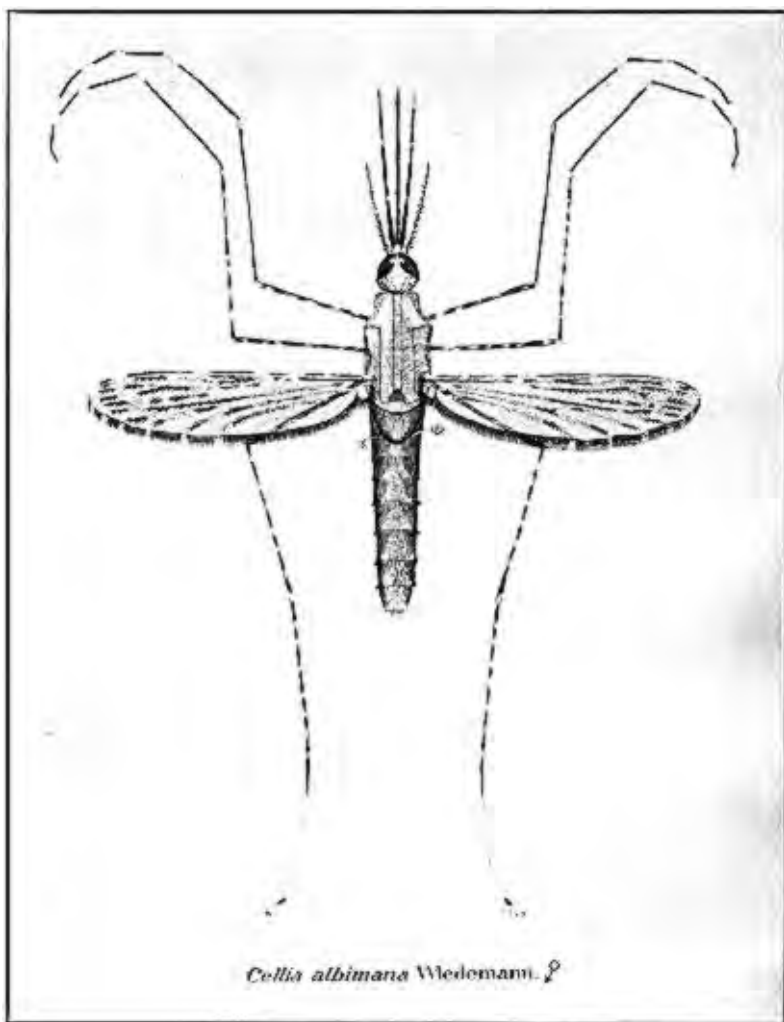
CELLIA TARSIMACULATA.

This mosquito resembles *A. albimanus* very closely, except for the different arrangement of the white bands on the palpi.

Positive to malaria.

Habitat.—Canal Zone, Central America, and southward.

Breeds in brackish water.



CELLIA STRIGIMACULA D. and K.

Proboscis black; palpi as long as the proboscis, black, a few whitish scales at the bases of the last two and middle of the long joint. Occiput black, clothed with erect black scales, a group of white ones in the center of the vertex, a tuft of pale hairs at the vertex.

Mesonotum narrow, elongate, grayish, pruinose, a black spot below the lateral angle and one on the antescutellar space; vestiture of fine pale hairs rising from small black tubercles. Scutellum collar like, grayish, with a black spot in the middle, clothed with pale bristles. Pleura and coxæ blackish with fine hairs, the coxæ with patches of white scales.

Abdomen with the tip truncate, brownish black, clothed with numerous fine pale hairs; a row of lateral segmental posterior tufts of black spatulate outstanding scales; beneath with tufts of black scales and with scattered white ones.

Wings hyaline, the petiole of the second marginal cell as long as its cell; basal cross vein distant about its own length from the anterior cross vein; scales of the veins ovate, white on the costa and first vein, pale yellow on the others, with black scales and spots as follows:

Three costal spots, the first small involving two veins, the others large, involving three veins, the membrane beneath infuscated; no apical spot; costa and first vein with two or three little black spots between each of the large ones, the outer spot involving the base of the fork of the second vein; each fork with two little spots beyond; third vein with two spots at the base and two at the tip; fourth vein with a spot at the base, a large one involving the base of the fork, three on the upper branch and two on the lower; fifth vein with some black scales at the base, five spots on the upper fork, two on the lower; sixth vein with some irregular black scales toward the base, a spot in the middle and one at the tip.

Legs long and slender, black, speckled with white. Femora, with about 8 spots; tibiæ with about 14, being about as many black scales as white ones; hind tarsi with 10 spots on the first joint; second, third, and fourth joints white at the base and tip, with a ring beyond the middle; fifth joint all white. Front tarsi with narrow white rings at bases and apices of the joints, the last entirely pale; mid tarsi not distinctly ringed. Claw simple.

Length.—About 5 mm.; of the wing, 4 mm.

Habitat.—Canal Zone, Central America, and southward.

CULICINÆ Theobald.

Of this subfamily only three species are known to be connected with the transmission of disease, namely, *Stegomyia fasciata* Fabr., the carrier of yellow fever; *Culex fatigans* Wied., a host for *Filaria nocturna*, and concerned in the transmission of dengue; and *Mansonia uniformis* Theob., proven a host for *Filaria nocturna* in Africa.

We will consider these in the order named.

Genus **STEGOMYIA** Theob.

Characters.—Head covered all over with broad flat scales and a few upright forked scales. Thorax with narrow curved and almost spindle-shaped scales; scutellum with broad, flat scales only. Palpi of ♂ short, small; ♂ palpi slender, acuminate or clavate, hairy. Venation much as in culex, but the fork cells are rather small. Scales of the wings broader than in culex. Larvæ with rather short respiratory tubes. Eggs laid singly.

STEGOMYIA FASCIATA Fabricius.¹

Head densely clothed with broad flat scales, black and gray on each side, a white patch in the middle extending back to the neck, a white patch on each side, a narrow white border to the eyes, and long black bristles projecting forward; antennæ blackish with narrow pale bands, basal joint black, with a patch of white scales on the inside, second joint sometimes pale testaceous at the base, pubescence and verticils dark brown; palpi black scaled, the last joint with pure silvery white scales inside and on the tip, sometimes entirely white; proboscis black; eyes black; clypeus blackish.

Thorax dark brown, covered with reddish brown to black, sometimes olive green, scales and ornamented with silvery white, as follows, a broad curved stripe laterally bending inwards about the middle of the mesonotum and continued back as a narrow line to the scutellum, two narrow submedian lines broken near the nape and near the scutellum, where a short median line replaces the other, the effect of the whole being much like a "jew's-harp;" scutellum with white scales and brown bristles; mesonotum brown; pleura dark brown, with several patches of silvery scales.

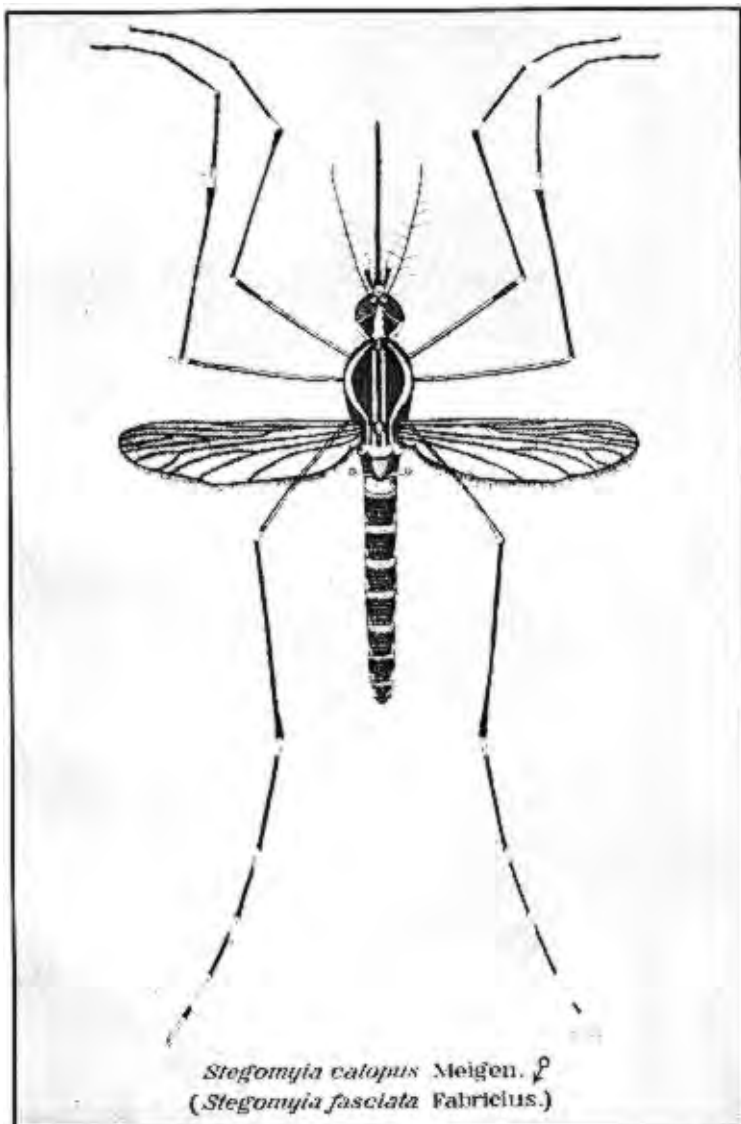
Abdomen dark brownish black, with basal bands of white scales and lateral white spots, somewhat triangular in shape.

Legs black, femora yellowish toward the base and with a small apical white spot, ventrally partly covered with white scales; tibiæ black, metatarsi (first tarsal joint) with basal white bands; fore and mid-tarsi with the first (second) joint basally white, rest black; hind tarsi all basally white except the ultimate joint, which is pure white; fore and mid-ungues equal, uniserrate, hind ungues simple.

Wings dark, clothed with long narrow brown lateral scales and short broad median ones; first submarginal cell longer and slightly narrower than second posterior; base of former a little nearer the base of the wing than the latter; posterior cross vein about one and a half times to twice its length distant from mid cross vein. Halteres ochraceous, or with fuscous knob.

Length.—3.5–5 mm.

¹ Experiments with *Stegomyia fasciata* Fabr. and *Mansonia uniformis* Theob. in the transmission of *Trypanosoma gambiense* have given positive results, and the work of the earlier authors has lately been corroborated. Fülleborn et M. Mayer Arch. f. Sch. u. Trop. Hyg. t. XI. 1907, p. 535, Experiences de Transmission du "Nagana" par Stomoxys et par les Moustiques du genre *Mansonia*. Gustave Martin, Leboeuf et Roubaud, Bull. Soc. Path. Exot., t. I, p. 355, Transmission du *Trypanosoma gambiense* par des moustiques. F. Heckenroth et M. Blanchard.



♂ Very like female; palpi slender, acuminate, practically nude, with four white basal bands on the joints. Fore claws unequal, the larger uniserrate.

There is much variation in the color, some specimens from the Philippine Islands being an olive brown, but the markings on the thorax are distinctive.

Var. MOSQUITO R. Desvoidy.

Differs from the type in that the narrow submedian white lines are lacking.

Var. LUCIENSIS Theobald.

Differs from type in having black tip to distal joint of hind legs.

Var. QUEENSLANDENSIS Theobald.

Differs from type in coloring of thorax, and in abdominal marking which have both basal and apical light bands and a median light stripe, the whole abdomen light.

All the varieties are met both in the Philippine Islands and on the Western Continent, and the typical form is widespread throughout the islands, in Central America, the West Indies, and in many of the Southern States, though not always present during the whole year.

Carries yellow fever.

Breeds in small receptacles, barrels, buckets, odds and ends,¹ tin cans, earthen jars, etc., in or near habitations, and in tree holes; is a continuous breeder and needs much and continued care to control.

The eggs are elongate, blackish in color and rather sparsely studded with minute hemispherical bodies of whitish secretionary matter.

The larvæ have the rather unusual habit of occasionally swimming, and wriggle along the surface of the water as do the larvæ of certain *Anopheles*, and feed largely upon amorphous matter and the macerated remains of small crustaceans (Cyclops, etc), and minute fragments of aquatic plants.

¹ Boyce, Sir Rubert. The Prevalence, Distribution, and Significance of *Stegomyia fasciata* in West Africa. Bull. Ento. Res., vol. 1, p. 233.

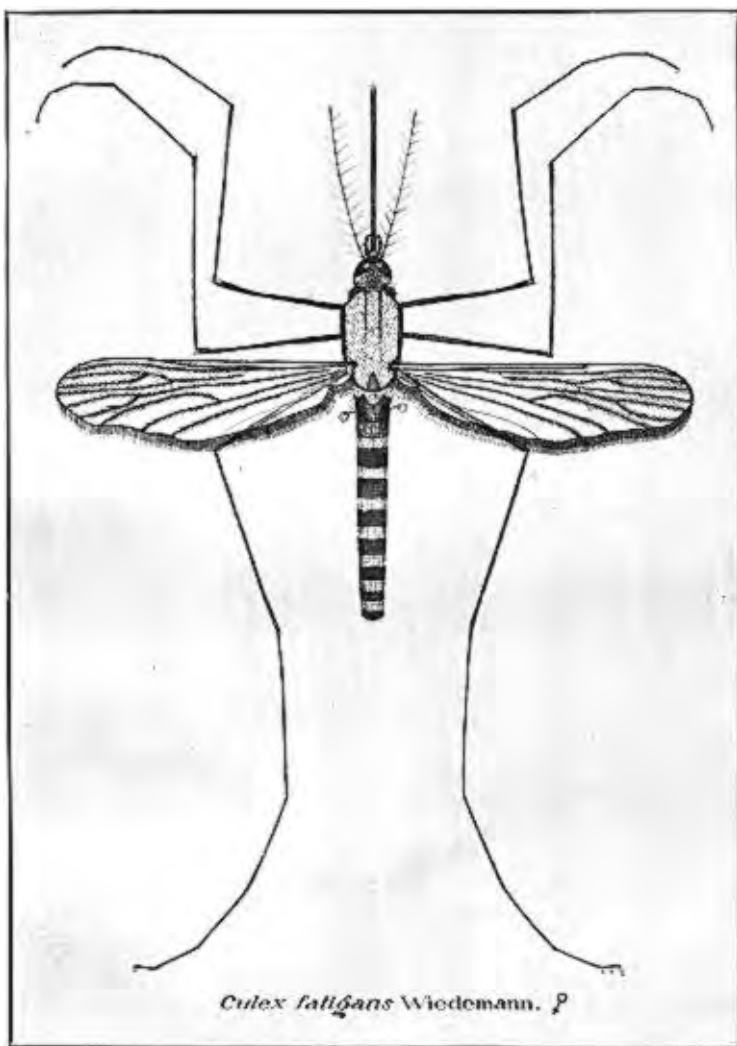
CULEX FATIGANS Weidemann.

Thorax brown, with two distinct dark lines on the denuded surface, covered with pale golden curved scales and with two more or less distinct bare parallel dark lines, and three rows of dark bristles, ornamentation variable. Abdomen dark brown to black, with basal white or pale creamy curved bands and white lateral spots; venter white or yellow scaled. Legs dark brown; bases of the femora and coxæ pale, knee spot and sometimes the apex of the tibia with a faint yellow spot; unguis of the ♀ equal and simple; in the ♂ the fore and mid unguis are unequal and uniserrated, the hind equal and simple. Wings with the first submarginal cell longer and narrower than the second posterior cell, its stem variable in length, never less than one-quarter the length of the cell; posterior cross vein distant twice (or more) its own length from the mid cross vein.

♀. Head brown, covered with pale golden-brown to creamy curved scales and a few scattered black, dark brown, and occasionally ochraceous upright forked scales, flat creamy white scales laterally, and a faint pale narrow border round the eyes, numerous black and brown bristles; antennæ dark brown, with pale pubescence; basal joint pale ferruginous to ochraceous, basal half of the second joint pale ferruginous; palpi densely covered with deep brown scales, and in some specimens with a few pale gray ones, and with numerous small black bristles; proboscis covered with dark brown to violet-black scales, sometimes paler in the middle, and with a pale apex.

Thorax brown, with two darker lines on the denuded surface, sometimes with traces of a third median line, covered with bright golden to pale golden or almost fawn-colored curved scales, some being rather broader than others; there are also three rows of black bristles, the median one ending at the bare space before the scutellum; scutellum dull ochraceous, with pale golden to creamy curved scales and brown border bristles, which vary in number on the median lobe; metanotum pale chestnut-brown, in some specimens with darker markings; pleura pale testaceous, with three or more small patches of pale, almost white scales.

Abdomen covered with brown to deep purplish-brown or almost black scales, each segment with a basal white band rather expanded in the middle, and with white lateral patches, which show especially in gorged specimens; posterior borders of the segments with pale golden-brown hairs; venter with numerous dull white scales; the first abdominal segment is dull ochraceous brown (black in gorged



specimens), with two patches of dull violet-black or ochraceous scales and numerous golden-brown hairs.

Legs with the coxæ deep ochraceous; femora deep brown above and at the apex, gray beneath, and tipped with a few yellow scales; tibiæ deep brown, with a deep ochraceous apical spot (sometimes absent), and with pale dull brown bristles; metatarsi and tarsi deep brown to almost black, with dull ochraceous reflections in some specimens; hind metatarsi a little shorter than the hind tibiæ; ungues equal, simple, and of moderate size.

Wings longer than the abdomen, the veins clothed with brown and purplish-brown scales; long scales on the whole of the second and fourth long veins, also on the third, the upper branch of the fifth, and the end of the sixth, as well as on both the branches of the fork cells; the first submarginal cell longer and slightly narrower than the second posterior cell, its stem short, always more than one-fourth the length of the cell; the stem of the second posterior cell longer than that of the submarginal cell, but not nearly as long as its fork; the posterior cross vein a little longer than the mid cross vein, distant from the latter always more than its own length, usually about twice its own length distant. Halteres ochraceous, slightly fuscous at the top.

Length.—4.5 to 5.5 mm.

♂. Head ornamented as in the ♀; antennæ deep umber-brown, with pale bands and deep brown verticillate hairs; basal joint large, paleochraceous; palpi deep ochraceous, covered with brown scales, with a single pale band toward the basal third, longer than the proboscis by the last joint and nearly half the penultimate joint, the last joint tapering to a point, just a little longer than the penultimate joint; clothed on each side of the last two joints with moderately long but scanty dark brown hairs, which also exist at the apex of the antepenultimate joint; proboscis deep ochraceous, swollen toward the apical end, covered with deep purplish-brown scales; apex testaceous, sharply acuminate.

Abdomen narrow, covered with brown scales, deep purplish-brown to almost black in some specimens, with basal white bands, which on the last few segments spread out laterally; venter with gray or dull white scales, clothed above and laterally with numerous golden-brown hairs.

Wings with the bases of the fork cells nearly level; the first submarginal cell from one and a half to two and a half times as long as the stem; stem of the second posterior cell about as long as the cell; posterior cross vein about twice its own length distant from the mid cross vein.

Legs rather more ochraceous than in the ♀; fore and mid ungues unequal, dark brown to black; in the fore legs both are toothed, the larger one having a long blunt tooth about the middle, the smaller a

sharp pointed one toward the base; in the mid legs the unguis are very similar, but the larger tooth is a little more curved; hind unguis equal, small, moderately curved.

Length.—4 to 5 mm.

Habitat.—Madras (Goodrich) (12.12.1899); Calcutta (Daniels) (6.3.1899); Quilon, Travancore (James); Naini Tal (Giles); Bengal (Green); Singapore (Hanitsch) (4.9.1899); Hongkong (Ford) (8.1.1900); Straits Settlements (Wray); Fu-chow (Rennie); St. Vincent, West Indies (Powell) (25.5.1899); St. Lucia (St. G. Gray) (2.5.1899); Montserrat (Norris) (7.7.1899); Jamaica (Grabham) (8.2.1900); Panama (Mallet) (22.9.1900); Para (Churchill) (12.4.1899); Demerara (Quelch) (16.6.1899); Rio de Janeiro (Lutz) (4.7.1899); Buenos Aires and Argentine generally (Arribalzaga); Bermuda (Harvey) (16.8.1899); Durban (Christophers) (12.2.1899); Mombasa (McKay) (76); Pemba Island, East Africa (Dr. R. O. Sullivan-Beare) (11.10.1899); Bupengary, Queensland, (Bancroft); Australia, widespread (Skuse); Gibraltar (Birt); Portugal and Spain (Theobald); Egypt (Meigen); United States (Massachusetts, Maryland, District of Columbia, New York, Illinois, Minnesota, Nebraska, Kentucky, Texas, Virginia, New Jersey, Connecticut, etc.); Cuba (Lazear); Upper Burma (Watson) (94.4); Punjab (Datta) (73); Senegambia (Rees) (73); New Amsterdam (Rowland) (61); British Honduras (74); Belize (9.99); Fiji (Joynt) (68); Zozufferpur, Behar, Bengal (Green) (88); Nairobi, Zanzibar (Mackinder) (85); Mukerian, Hoshiarpur, India (Datta) (97); widespread in the Philippine Islands (1901-1913).

Date of capture.—In Hongkong and Singapore in July; Para in March and May (Churchill); Demerara in April and May (Quelch); St. Lucia in May (St. G. Gray); Jamaica in December (Grabham); Durban in January (Austen); Pemba Island, East Africa, in August (O. Sullivan-Beare); Mombasa in May; Bermuda in July (Harvey).

The following dates are given by Howard in America: Massachusetts, September to November; Maryland, in November and December; District of Columbia in January, March, May, June, July, August, October, November, and December; New York in May, July and August; Virginia in June and October; New Jersey in May; Texas in May, etc.

MANSONIA UNIFORMIS Theobald.

Palpi yellow scaled; proboscis yellow, with a broad black band near the apex and black scales at the base. Thorax brown, with chestnut and golden-brown scales in the center, paler ones at the sides, forming pale areas at the sides of the central chestnut-brown portion. Abdomen brown, with yellow and white lateral patches and a few ochraceous patches on the dorsum; venter white and ochraceous. Legs with the femora and tibiæ mottled and banded, metatarsi with basal and mid pale bands, tarsi basally banded white.

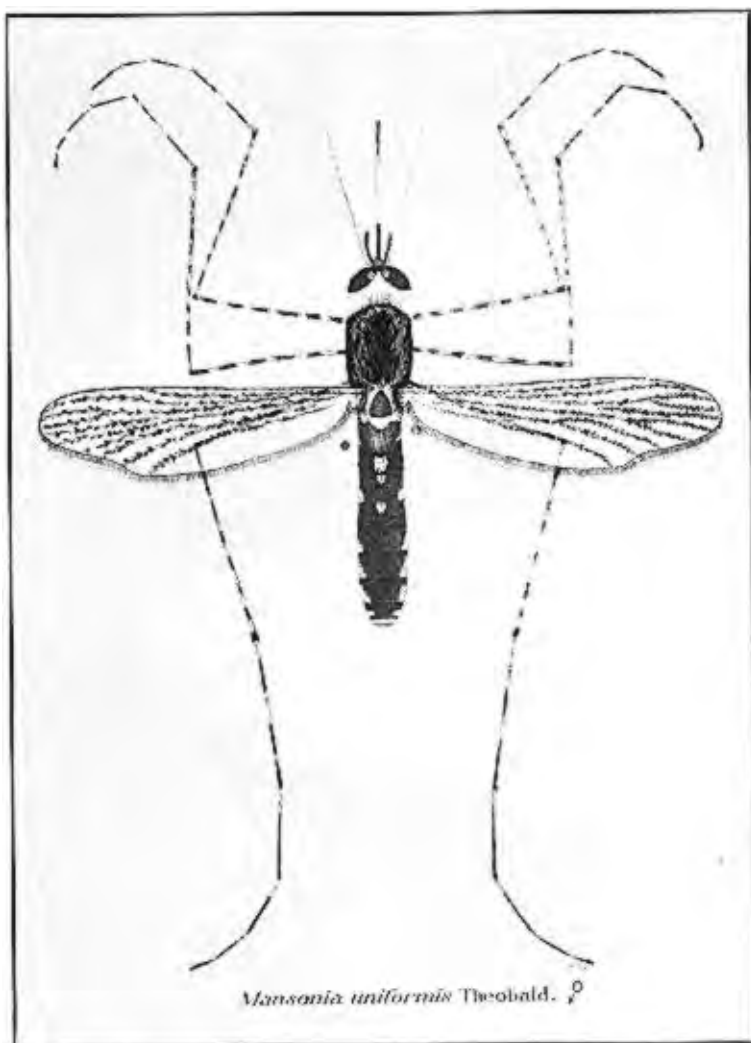
♀. Head purplish-brown, with curved white scales and black upright forked ones, slightly ochraceous at the sides; eyes purple and white, with a border of white scales; antennæ brown, basal joint bright yellowish, and also the base of the next joint, remainder faintly banded; palpi yellowish, with a few blackish scales; proboscis ochraceous, with a broad black band near the apex, tip yellowish, and a few black scales at the base.

Thorax brown, with a purplish-brown tinge, covered with golden-brown scales in the center, more or less arranged in rows, on each side a broad stripe of whitish scales, a patch of similarly colored ones posteriorly; sides of the mesonotum with golden scales, and on each side, toward the scutellum, a large roundish bare spot (this does not always appear prominently); scutellum chestnut-brown with purplish-brown reflections, with scattered white scales and a border of bright brown bristles, seven bristles on the mid lobe and five on each side; metanotum brown; pleura with two patches of white scales.

Abdomen covered with dark-purplish-brown scales, with patches of white and yellow scales laterally, the white on the posterior border of the segments; a few ochraceous patches on the dorsum; posterior borders paler, with golden hairs, the last few segments when denuded testaceous; venter with white and ochraceous scales on a dark ground.

Legs with the femora yellowish, mottled with dark scales and patches of white, no distinct banding; anterior tibiæ dark in front, with about seven white spots; posterior tibiæ with five white and six dark bars in front, yellowish beneath; metatarsi of all the legs pale at the base and banded white in the middle; the first two tarsal joints of the fore and mid legs basally white; all basally banded in the hind legs; ungues simple.

Wings mottled with dusky and pale creamy broad scales; posterior border with dark and light basal scales; border scales small; fringe



dark; posterior cross vein about twice its own length distant from the mid cross vein; the base of the fork of the second posterior cell slightly nearer the base of the wing than that of the first submarginal; the cells of about equal width, the latter slightly the longer. Halteres with a pale stem and dark knob.

Length.—4.5 to 5 mm.

Habitat.—Quilon, Travancore, South India (S. P. James) (7.4.1900); Taiping, Perak (Wray) (22.11 and 21.12.1899), Philippine Islands.

Date of capture.—In south India, February (James, February 8). Positive to *Filaria nocturna* in Africa.

Breeds in marshes. Dr. Graham found they would not develop or even lay their eggs in fresh water with the native West African algæ in it, but were flourishing in water holes containing catfish (no small fish observed) where the natives bathed and washed their clothing, and oxen going to drink left excrementitious material at the edges.¹

MANSONIA AFRICANUS Theobald.

Proboscis with median broad and narrow apical yellow bands. Thorax dark brown, ornamented with narrow golden brown and silvery scales, the silvery ones forming more or less two spots on the mesonotum and occurring on each side of the posterior half of the thorax. Abdomen dark brown; the basal segments with basal median yellow spots, the apical segments with yellow apical bands; there are also white apical lateral spots; venter pale, with creamy scales, apex often mostly white scaled. Legs dark brown, banded and mottled with white. Wings with black and yellow scales.

♀. Head brown, with narrow curved gray scales and flat white ones at the sides, a white border round the eyes and numerous long, upright forked dark brown scales; proboscis dark brown to almost black, with a broad median yellow band and a yellow band at the apex; palpi covered with dark-brown scales, apex white scaled, and there is also a band toward the base; antennæ brown, broadly banded with gray, the gray bands involving the base and apex of contiguous joints; basal joint testaceous, second joint pale testaceous, with a few black scales; clypeus deep testaceous.

Thorax deep brown (when denuded showing two parallel median gray lines), covered fairly thickly with narrow curved hair-like golden-brown and silvery scales, arranged as follows: A broad median band of golden-brown scales, which extends back to the bare space in front of the scutellum, and which then sends a branch down on each side of the clear space; there is also a patch on each side of the mesonotum in front of the wings, apparently more or less connected with the median golden-brown area by a narrow band of similar

¹ Graham, W. M. The study of Mosquito Larvæ. Bull. Ent. Res., Vol. I, p. 51.

scales extending to the front of the mesonotum; the white scales occur in front and on each side of the golden-brown areas, and form two more or less distinct spots on the anterior third of the mesonotum, and also flank the bare space in front of the scutellum between it and the fork of golden-brown scales; scutellum bright brown, with narrow curved white scales, the bristles arising from black spots, there being six median golden-brown bristles; metanotum deep brown; pleura brown, with dark patches and white scales.

Abdomen dusky brown, covered with deep brown scales, the first segment with a large median patch of yellow scales, the second and third with basal creamy yellow patches, the rest with more or less apical yellow bands, but the last three segments have dull ochraceous scales scattered over at least their basal half, whilst the apical one has many white scales; the segments have also lateral apical pure white patches, posterior borders of the segments with short brown hairs; venter densely covered with pale ochraceous scales.

Legs dark brown, with bands and mottlings of white, ochraceous when denuded; femora with two pale bands, the one near the apex white; tibiae with irregular black and white scaled patches; metatarsi pale at the base and with a white band in the middle, first two tarsi of the fore legs with basal white bands, the first three in the mid legs and all in the hind legs; ungues equal and simple.

Wings mottled, with brown and yellow scales; veins yellowish, a few long scales on the first long vein only; border scales small, rather long, flat or slightly convex at the apex, dark brown and yellow; first submarginal cell longer and narrower than the second posterior cell, its base about level with that of the other fork cell, about one and a half times as long as its stem; stem of the second posterior cell about half as long as the cell; posterior cross vein nearly twice its own length distant from the mid cross vein. Halteres ochraceous, with a slightly fuscous knob.

Length.—4 to 4.3 mm.

Habitat.—Fort Johnstone, British Central Africa; Chiromo, Lower Shire, British Central Africa (Gray); Lagos (Strachan) (91); also British Central Africa (Daniels); Old Calabar (Annett), Philippine Islands.

Time of capture.—March (Fort Johnstone); June (Lower Shire); March (Lagos).

Theobald for a long time considered this to be identical with his *M. uniformis*, but lately Edwards states it is distinct, though very like it. There must be some uncertainty as to which species was used in the experiments with *filaria*. It has seemed worth while to add this to the description of *uniformis*, as it may easily be confused with that species.

Breeds in marshes.

BREEDING PLACES.

As our knowledge of the life history of mosquitoes has grown, our conceptions as to the breeding places of these insects have materially changed, and we now recognize possibilities of this sort in conditions that formerly would have been considered as having no connection with the development of these insects.

Speaking broadly, there are two general groups of breeding places, and these may require very different treatment—the hill country and the flatlands.

Until quite lately in the “hill country,” where typical little mountain rivulets run in the ravines, the breeding places of mosquitoes have been little considered, and it is quite possible that in the Temperate Zone they need be given little attention, for the disease-bearing mosquitoes probably do not breed there, but in the Tropics they may call for especial attention and care.

In the Federated Malay States, Dr. Malcolm Watson, in his remarkably successful fight against malaria, found that the usual care in keeping these mountain or hill streams free of grass and weeds, and the current running strongly, did not control certain mosquitoes, and that the prevalence of malaria in the people living near these places was not lessened in the least.

To quote his own words, Dr. Watson says:¹

“* * * On the hill land the chief carrier is *Nyssorhynchus willmori*, a mosquito which can not be exterminated in the ravines by open drainage, however quick the current,” and gives the following interesting account of his observations:

“In this hill land [coast districts of Selangor] the mosquitoes which are to be found are *Myzorhynchus umbrosus* (as in the flatlands), *Nyssorhynchus willmori*, and *Nyssorhynchus karwari*. Now the important part about these mosquitoes is, that if a ravine stream be kept free from grass and weeds *N. karwari* and *M. umbrosus* no longer breed in it, but *N. willmori* will breed in streams which have been absolutely free from grass and weeds for three years to my knowledge.”

“I consider that the eggs are laid in and the larvæ prefer the shallowest water possible [in the eye of the spring]; indeed, they are to be found in greatest abundance in ground with so little water on it that in order to take the larvæ it is often necessary to make an

¹ Prevention of Malaria in the Federated Malay States, p. 952.

excavation in the earth into which the water from the surrounding ground flows, carrying the larvæ with it. As these springs are very common at the head of the ravine, the presence of this mosquito in them probably accounts for the well-recognized danger of living at the head of a ravine." "From these springs the larvæ are carried down the streams, but they can not be entirely washed out even by the strongest currents or rains." "I have watched them at play in a clear pool at the foot of a rock down which water was flowing with considerable force." "The larvæ were playing, not exactly like trout, head to stream, but were floating round in the current, and every now and then one would swim right into the stream, up it a short distance, and then hang on the side of the apparently bare rock in the full strength of the current."¹ "As *N. willmori* is never found in the flatland, it is obvious that this mosquito requires water of a special character, and a character which appears to be water well aerated and quite free from vegetable decomposition."

All this is quite in opposition to our previous ideas of the breeding places of mosquitoes, but it is possible other mosquitoes will also be found to breed in swiftly running water. Dr. Watson controlled the situation by piping the water and putting it underground.

Nearly related in treatment, but really belonging to the flatland condition, are the pools formed at the sides and termini of ditches or running streams on hillsides, and which have been found hard to control. In such cases piping may also be necessary.²

In the flatland and generally in towns we have conditions with which we are more familiar, and which are easier and less expensive to control.

(A) The marsh, salt or fresh, may breed anophelines as well as some of the fiercest biters among the nondisease-bearing mosquitoes.

(B) Streams and ditches with grassy edges, where the water runs quietly; pools or ponds with grassy edges, perhaps more especially smaller ones, make efficient breeding grounds.

(C) Small depressions in the ground—hoof marks, wagon ruts, small hollows in plowed ground, even the heel mark of a shoe, if filled with rain or overflow water and left full for a few days, make excellent breeding places, such as are especially suited for *A. maculipennis* and several of the oriental anophelines.

(D) Soiled water has not usually been considered as fitted for the breeding of anophelines, but in the last few years larvæ of *M. indefinita* have been taken in the soiled, soapsudsy water from bathhouses in the Philippine Islands, and in the United States *A. punctipennis* in a "stream that was so foul it resembled an open sewer," and

¹ Prevention of Malaria in the Federated Malay States, p. 105.

² This was done by Maj. Russell, Medical Corps, at Fort Washington, with most satisfactory results.

Smith goes on to say he "has never found a pool so insignificant or a stream so rapid but that somewhere in it *Anopheles* can breed." ¹

(E) The small amounts of water collecting in a sagging gutter of a house, drainpipes, the sulci of plants, knot holes in trees, the hollows in the internodes of bamboo, especially where used in construction, the tin cans placed under the legs of a table to keep ants from it; in fact, any body of water, no matter how small, if left undisturbed for a few days, may prove to be of grave danger, and it is not necessary that the water should be clean or merely soiled, for *Culex fatigans* breeds in absolute filth.

Anophelines as a rule breed at some distance from houses, some are purely sylvan breeders, but *Stegomyia fasciata* and *Culex fatigans* are definitely house breeders, and are found near or in houses in any small receptacles containing water.

Mansonia uniformis and probably *M. africana* breed in swamps, often in "burrow pits," pretty well covered with small aquatic plants.

¹ Smith, J. B. Report Ex. St. N. J.

LIFE HISTORY.

EGGS.

The eggs of mosquitoes vary in (a) method of oviposition, (b) markings, and (c) place where laid.

(a) As mentioned above, the eggs of mosquitoes are laid in rafts, as in one group of the *Culicinæ*, or singly, as in the *Anophelinæ*, and this difference is correlated with the shape and retractibility of the eighth segment of the female abdomen.

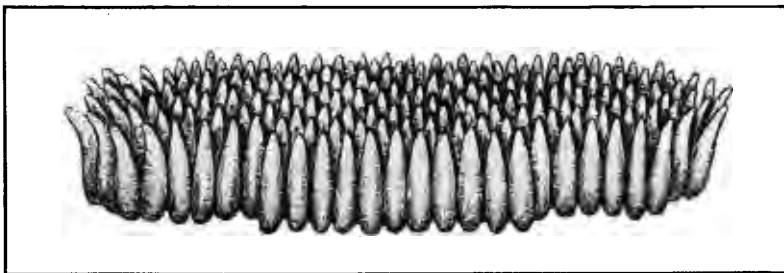
(b) The size and marking of the eggs varies in different groups. All the anophelines have a "float," a hydrostatic organ composed of a partial envelope, and may be recognized by this peculiarity. This organ is variously shaped and developed in different species; in one species it has become almost obsolete, while in a Brazilian species it is remarkably developed, completely surrounding the egg, and forming several air chambers about it. *This "float" is peculiar to the anophelines.*

(c) Oviposition may take place on water, on surfaces of plants or receptacles near the water, or on or in very wet ground. Most of the anophelines are believed to lay the eggs on the water, but Dr. Watson found that *N. wilmori* evidently laid its eggs in the wet ground. *G. sollicitans*, the salt-marsh mosquito of the Atlantic coast, lays its eggs in the fall in the moist ground of the marshes, where they remain all winter, hatching with the warm weather and additional water of the spring. *Stegomyia fasciata* is essentially a tree-hole breeder, but also breeds in and near habitations, laying its eggs near the water, and waits for additional water to reach the eggs. In this way it would be quite possible for this mosquito to lay its eggs on the sides of a receptacle (in or near a house) from which the water might gradually evaporate, and later, even after months, be refilled, when the eggs would hatch and a very surprising increase of mosquitoes result.

Culex fatigans lays its eggs in masses, and in practically any place, large or small, where the water is quiet and there is enough water to keep the place damp enough to hatch the eggs, the water ranging from clean rain water to absolute filth.

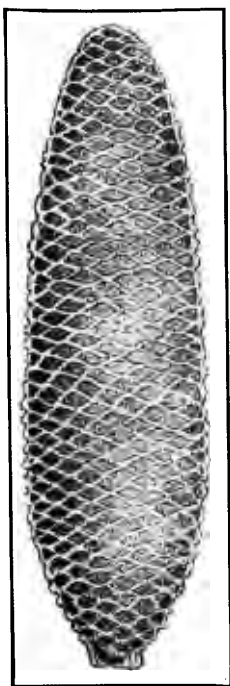
Mansonia uniformis and *M. africana* also lay their eggs in masses, and, so far as known, in marshes. It is a fierce biter, and in the vicinity of marshes very troublesome.

As indicated above, the viability of the eggs is markedly variable, and probably differs with each species, so that no dependence can



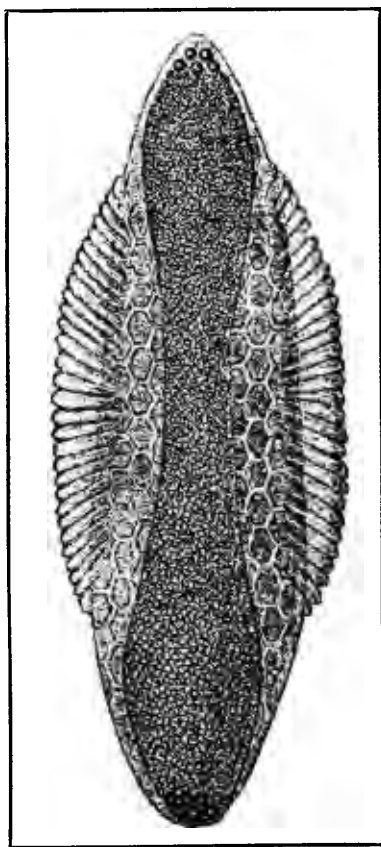
After Howard.

Egg raft. *Culex territans* Walk.



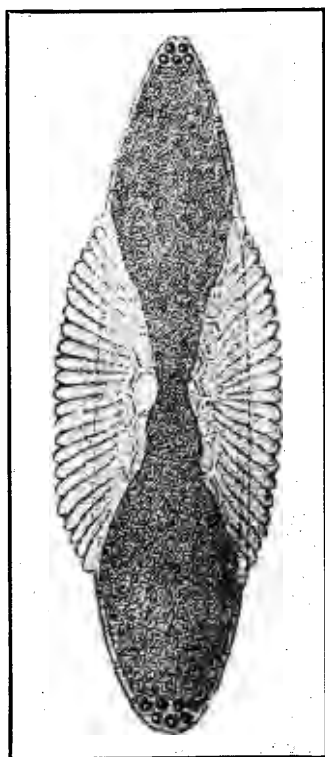
After Howard.

Egg. *Stegomyia fasciata*.



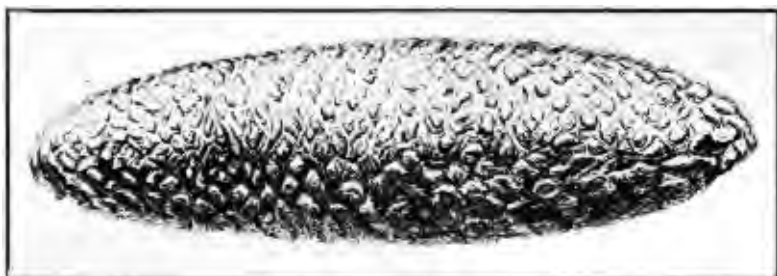
After Howard.

Egg. *Anopheles crucians*.



After Howard.

Egg. *Anopheles maculipennis*.



After Howard.

Egg still further enlarged. *Stegomyia fasciata* Fabr.

be placed on any general statement in the matter; it is necessary to know what species is being dealt with, or lacking that, to make original observations, keeping in mind the possibilities of the dry egg living for months, to hatch when some favorable condition of moisture reaches it. For instance, one of the salt-marsh breeders of the Atlantic coast lays its eggs in the moist ground of the marsh, where they stay for months, and then hatch apparently all about the same time; but with the salt-marsh breeder of the Pacific coast, which also lays its eggs in the moist ground, the eggs are hatched at monthly periods corresponding to the high tides.¹

LARVÆ AND PUPÆ.

These immature forms vary with the group and species to which they belong, and as the larvæ molt several times, even the age is indicated. Some of these differences while of phylogenetic value are not easily recognized by those not accustomed to their study, but the presence or absence of the respiratory siphon is easily seen and is always indicated by the angle at which the larvæ float. It is always absent in the anophelines, on which account they float horizontal to the surface of the water, but it must be remembered that other aquatic larvæ also have this peculiarity (e. g. *Chironomidæ*), and that this position does not necessarily mean that the larvæ are anophelines, or even that they are mosquito larvæ. The respiratory siphon varies in length in different genera, but is present in all mosquito larvæ except anophelines.

The food of larvæ is often spoken of as if confined to algæ, but this does not cover the subject; larvæ eat small crustaceans (*Daphnia*, etc.), and other microscopic animals, débris of larger dead animals, possibly some of the lower fungi (bacteria), while some are markedly predaceous, eating living organisms of nearly their own size, and some are even cannibalistic.

The lifetime of the larvæ depends partly on species, partly on conditions of temperature and food, and may last only a few days, or under unfavorable circumstances be lengthened to several months.

The pupæ, however, are short lived; no food is taken in this stage, and the development is necessarily rapid.

The breeding places where these forms may be found have already been indicated, but it must be remembered that it often requires much patience, a real determination to find them, a good deal of care, and repeated effort, not only to secure specimens for study or breeding, but even to see the larvæ in the places where they dwell.²

¹ Howard, L. O.; Dyar, H. G.; Knab, F. The mosquitoes of North and Central America and the West Indies. 1912.

² The color of the larvæ renders many of them inconspicuous, often being a soft gray, or closely resembling the tangle of root masses and débris in which they live, but a few are brilliantly colored, and in this respect may be misleading.

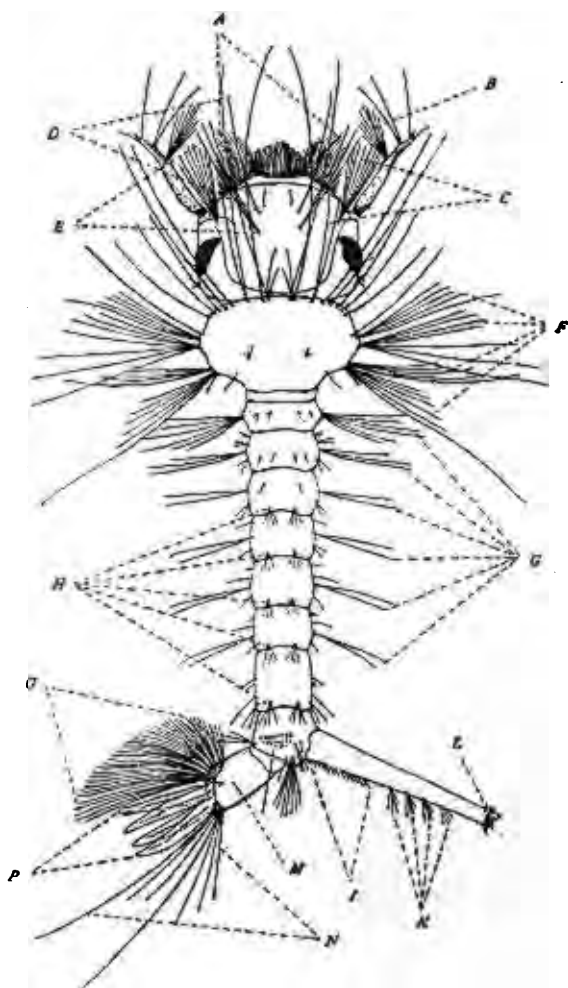
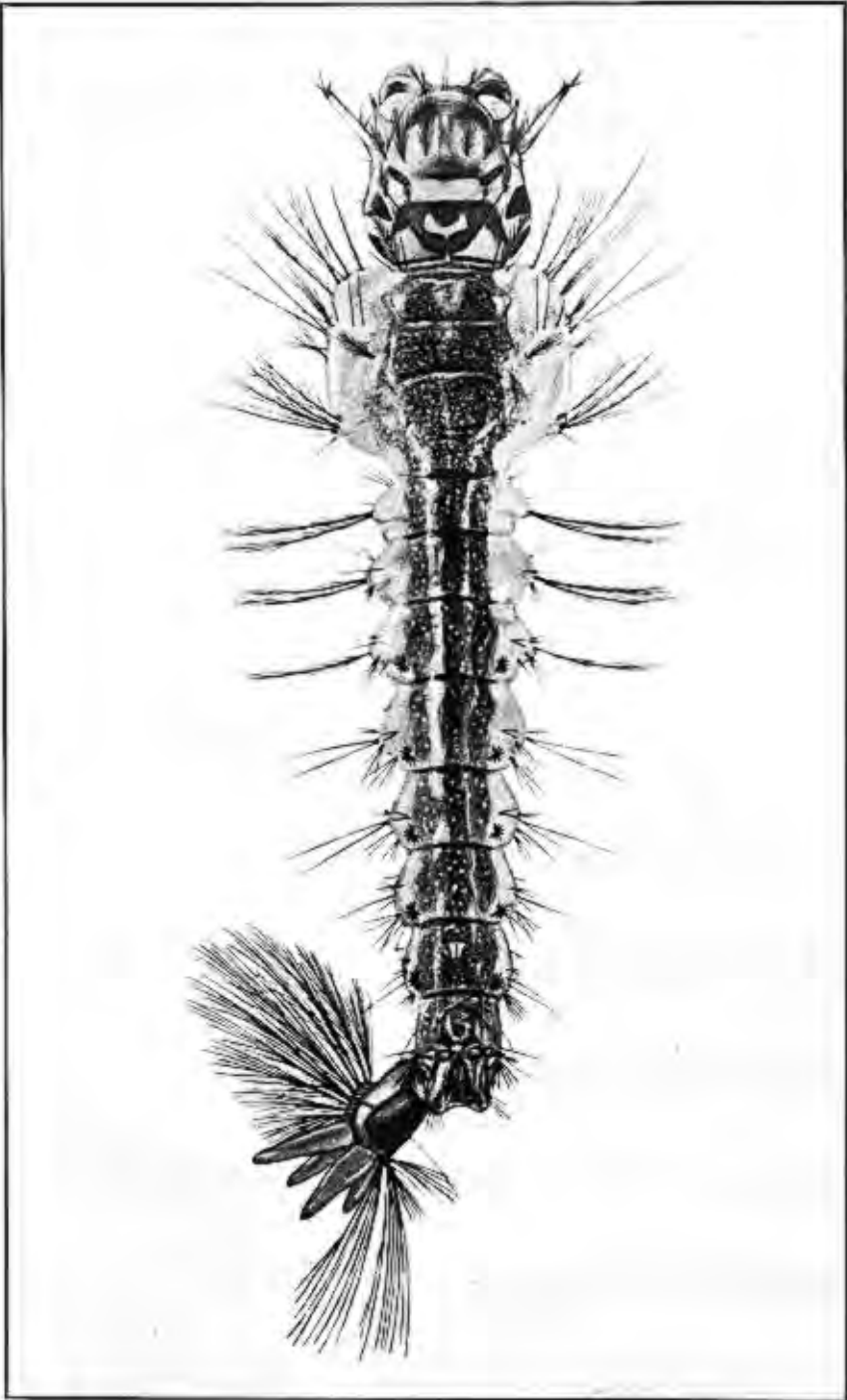


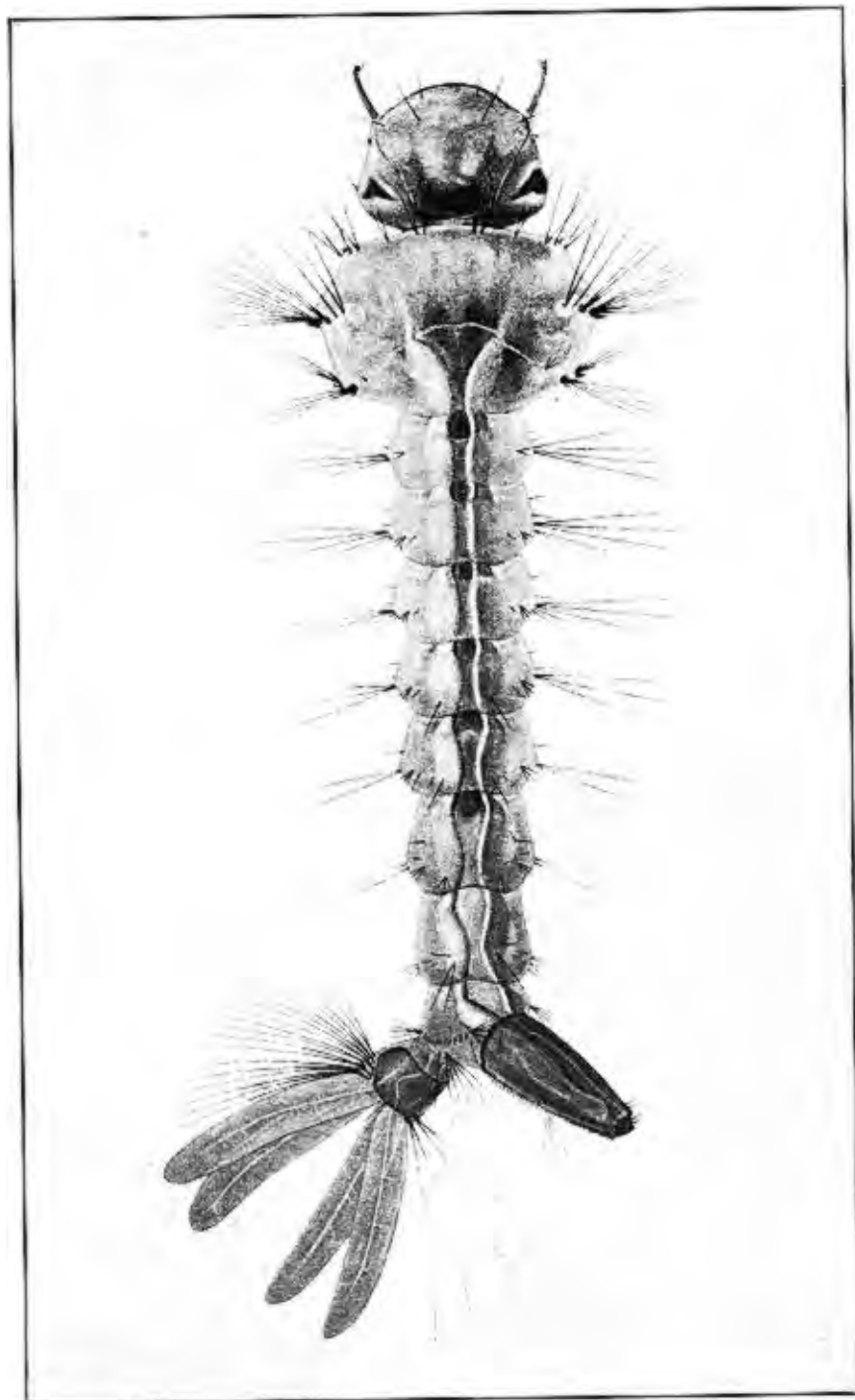
DIAGRAM OF CULICID LARVA.

- | | |
|-------------------------------|-------------------------------------|
| A. Mouth brushes. | I. Pecten of air-tube. |
| B. Tuft of antenna. | K. Hair tufts of air-tube. |
| C. Ante-antennal tuft. | L. Apical spine of air-tube. |
| D. Lower frontal tuft. | M. Anal segment. |
| E. Upper frontal tuft. | N. Subdorsal tufts of anal segment. |
| F. Thoracic hair tufts. | O. Ventral brush. |
| G. Abdominal lateral tufts. | P. Anal gills. |
| H. Abdominal subdorsal tufts. | |



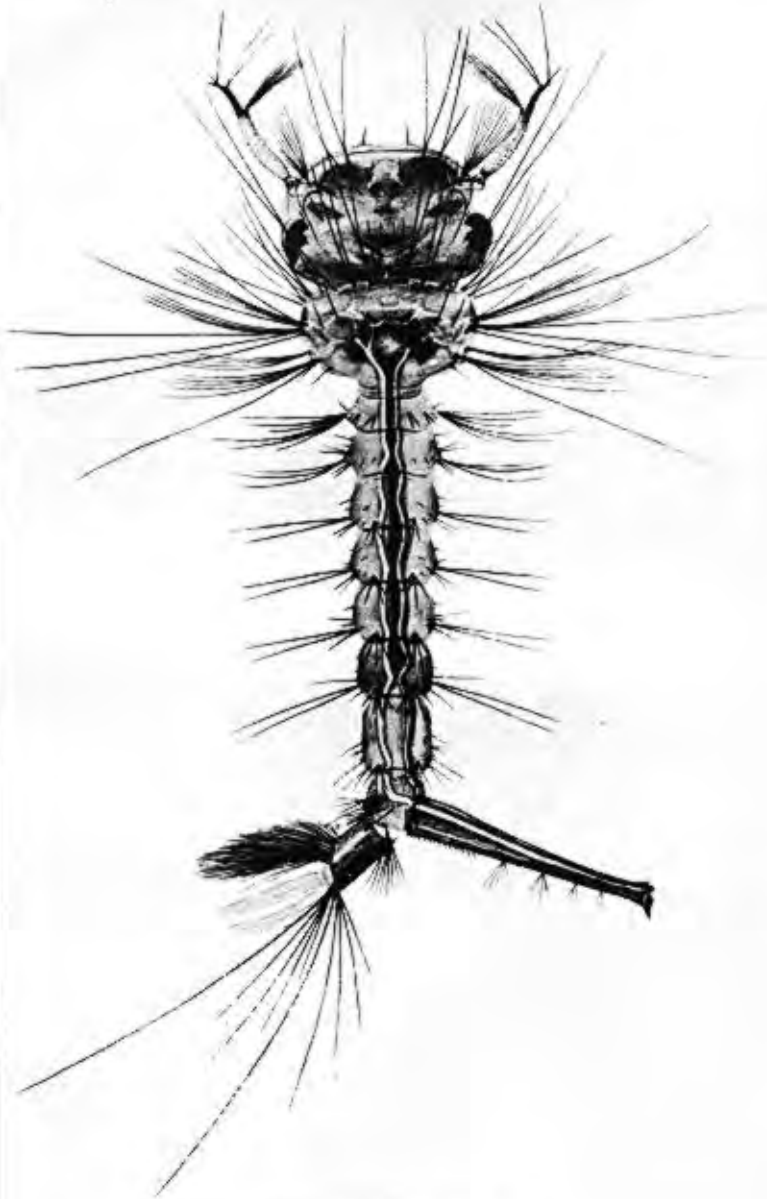
After Howard.

Larva. *Anopheles punctipennis* Say. No respiratory siphon.



After Howard.

Larva. *Stegomyia fasciata* Fabr. Respiratory siphon, heavy, comparatively short.



Larva: *Culex territans* Walker.

Larva. *Culex territans* Walk.

After Howard.

In collecting larvæ for study it is always better and sometimes a necessity to secure a supply of the water in which they were taken, and if they need animal food, to furnish them with broken small insects (flies, etc.), so that the development may be normal, for adults raised from unfed larvæ are often quite unlike the normal species.

ADULTS (IMAGINES).

The general appearance of mosquitoes varies from extremely small dark gray species to large and brilliantly colored forms, the intermediate colors including various markings in black and silver (*Stegomyia fasciata*) and brown and yellow, as in many anophelines, and *Mansonia uniformis* and *africana*. They may have curved or straight probosces, long or short palpi, and the head scales may be hair-like, curved or flat scales or forked scales, or the last three together, and all these differences may occur without regard to sex.

They develop in and emerge from the pupæ and often stand for a moment on the discarded pupal skin while they dry and spread their wings. How long a time elapses from this emergence to the taking of food and of mating is probably variable and may depend on the accessibility of food and the number of males present, but mating always occurs in a few days. Many theories have been advanced as to the value of the antennæ as a means of communication between these insects and as to whether the male seeks the female or the reverse, but it does not seem worth while to discuss these points in this paper.

The food of mosquitoes seems to be, in nature, fruit and other plant juices, this being especially true of the males, and the females add the blood of nearly any animal, apparently most often warm-blooded animals, although there are records of mosquitoes attacking frogs, turtles, and lizards, and one group feeds entirely on the liquid from the crop of an ant, which the mosquito forces the ant to disgorge. Most of the males do not have the mouth parts developed so as to form piercing organs and are therefore not fitted for bloodsucking, but occasionally a specimen is taken that shows this development as in the female, and this of course accounts for the occasional report of males sucking blood. In some of the larger species (*Megarhinus*), which have the very long and curved proboscis, the proboscis is entirely unfitted for piercing both in the male and female, so they are never bloodsuckers.

Perspiration is said by Goeldi to attract mosquitoes and that he has seen both males and females sipping it with apparent enjoyment.

Flight.—There has been much discussion over the length of flight of mosquitoes, and some of the discrepancies probably occur because different species were under observation, this being another point on which no generalizations can be made. Dr. Watson found that about half a mile was a limit of safety in the mosquitoes (anophelines) he

was combating in the Federated Malay States. Capt. C. F. Craig, Medical Corps, United States Army, in his observations at Camp Stotsenburg, P. I., had every reason to think that the anophelines there flew for $2\frac{1}{2}$ miles,¹ and in the very interesting experiments made by the department of sanitation in the Canal Zone, Panama, adult anopheles were stained and liberated and afterwards "collected on the opposite side of the river, at the locks and in houses 4,700 feet from the liberating station,"² while the evidence leads one to believe that many specimens of these anophelines frequently flew to even greater distances (nearly 2 miles), the main flight in both cases occurring between 6 and 8 p. m. The report contains the interesting statement, "It should be stated that the anopheles' flight was decidedly marked and was easily noted by half a dozen witnesses, when their attention had been drawn to it. Even so, not one person in areas thickly infested did note the flight until shown the way to observe it." Dr. J. B. Smith, in his work with the New Jersey mosquito, *G. sollicitans*, found that it flew 40 miles.³ This latter observation easily explains how Army stations in the vicinity of New York may be kept free of breeding places for this species and yet the garrison suffer tortures from this fierce biter, but it is however not true of the *Anopheles* of that district; its breeding place must be closer at hand.

Time of activity.—The anophelines are for the most part accredited with biting in the twilight or during the night, but *M. funesta*, *M. barbirostris*, and probably some others attack freely in the daytime; *S. fasciata* is for the most part active in the daylight, but in the Philippines I have seen it bite (have been bitten by it) in lighted rooms at night. *Culex fatigans* flies preferably in the dusk and at night, but will occasionally bite in the daytime in darkened rooms. *Mansonia uniformis* also is a nocturnal biter, and probably *africana* also.

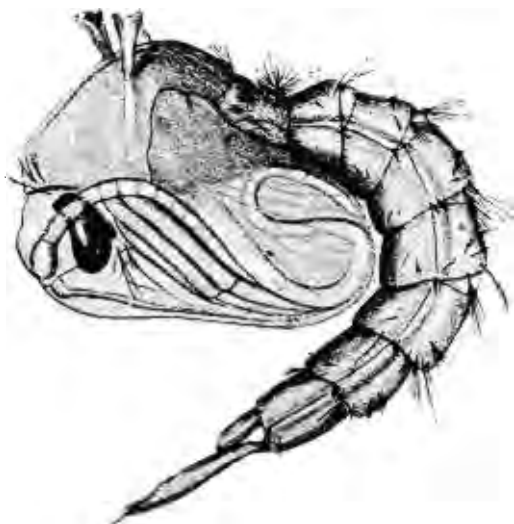
Longevity.—The male is short-lived; their only office is to fertilize the female and that being usually soon accomplished, the males die, living probably only a few days.

The lifetime of the female varies with species and conditions. Where the female hibernates, as do some anophelines in the Temperate Zone surely, and probably also in the Tropics when the "dry season" and "winter" are synchronous, the female must live some months. In the species that lay their eggs at one time in a mass, the life of the female is probably quite short, and a rapid succession of broods is to be expected. The females that deposit the eggs in small lots at intervals live much longer, often several months, and there are so many controlling conditions that it is impossible to

¹ Craig, C. F. The Malarial Fever, 1909, p. 69.

² Gorgas, W. C. Report Dept. of Sanitation, Isthmian Canal Commission, Jan., 1913; Dec., 1912.

³ Smith, J. B. Concerning Mosquito Migrations. Science, N. S. Vol. XVIII, No. 467, p. 761-764. Dec. 11, 1903.



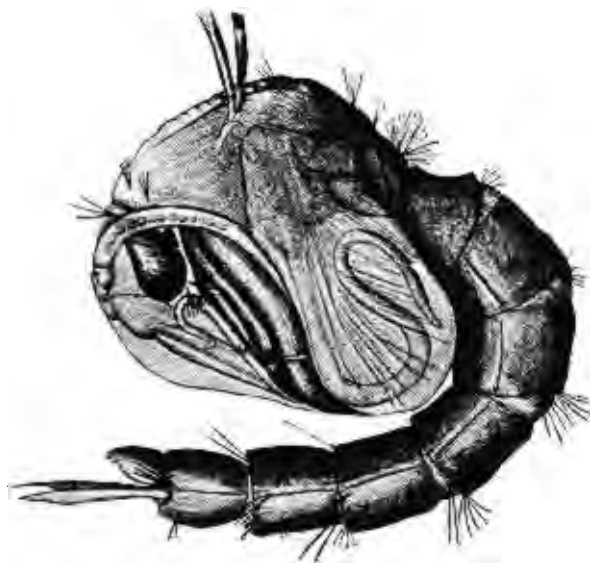
After Howard.

Anopheles punctipennis Say. (pupa).



After Howard.

Stegomyia fasciata Fabr. (pupa).



After Howard.

Culex territans Walk. (pupa).

make a general statement that will cover all cases. *Stegomyia fasciata* has been kept alive in captivity 154 days.

Hibernation or aestivation.—The unfavorable season is most usually passed in the egg state, but some mosquitoes undoubtedly pass this time as adults, and the specimens are probably all females. The place varies with the habit of the mosquito; dark parts of houses, as cellars, attics (in the Tropics, under the roofs, dark corners, etc.), stables, sheds, caves, hollow trees, crevices in the barks of trees, etc. They do not lay eggs during this period, but may feed if conditions allow of it, as is often the case in the Tropics.

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COLLECTING.

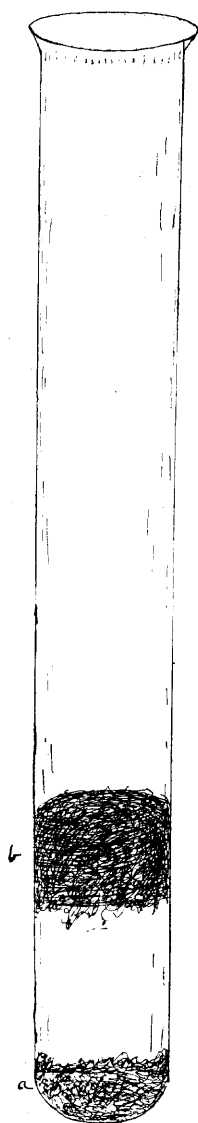
There are at least two quite different reasons for collecting mosquitoes, and the methods of collecting depend partly on the use to be made of the insects.

(a) If for entomological determination of the insects.

In this case the specimens may be taken either in flight, with a light net (preferably silk), and then immediately killed, or they may be taken at rest or feeding and killed at the time.

The killer may be one of several, but the one best suited for this work is probably the "chloroform tube," as suggested by Maj. Frick, Medical Corps, United States Army. To make it, take a large-mouthed but not too long test tube; put in it, at the bottom, a small wisp of absorbent cotton saturated with chloroform (or ether); leave a free space of half an inch to an inch above it, and fit tightly there a firm plaket of dry cotton, the smooth side uppermost; fit the tube with a cork, and keep it corked when not in use. This may be inverted over the insect, in the net, at rest or feeding, and if the mosquito be free, i. e., not tangled in the net, the insect may be dropped to the bottom of the tube (against the upper dry plaket of cotton) so soon as it is stupefied and remain there till dry. Several mosquitoes may be taken at one period, but it is absolutely necessary that these be taken out before another collection be made, and that no other insect except, perhaps, the very small flies often mistaken for mosquitoes be taken either in the net or in the killer when mosquitoes are being collected, because mosquitoes are very frail and easily injured. The specimens should be carefully slid from the killer into a small box or other receptacle for keeping, care being taken not to crowd too many into one box. If the insects are to be mailed, this box should contain a little absorbent cotton (just enough to steady, without crushing the specimens) onto which the insects are slid; a drop or two of 40 per cent formalin may be added, but should not touch or wet the specimens, and the cover should be put on at once, labeled with the place, date, and hour of collection, and shipped at once. Any frail box, whether paper or not, should be packed in a firm mailing box before shipping, as otherwise it is likely to be broken and perhaps the specimens lost during transportation.

Mosquitoes for identification are ruined and often rendered quite valueless if (1) wet, whether by the chloroform, by oil, as when collected around a greasy lamp, or by the disinfectant, or any other way, and should *never* be put in alcohol or other liquid for preserva-



I.

- I. Collecting and Killing tube
 a. absorbent cotton saturated with
 chloroform
 b. dry tightly fitted plug of
 absorbent cotton.



II

- II Tube for keeping collection in

tion; (2) if handled much, allowed to slide backward and forward in the killing bottle, or if not steadied by cotton during transportation, as this not only breaks off the appendages but denudes the insect of its scales, so that the markings are quite obliterated; (3) if crushed either in taking, in killing, or by the pressure of too much cotton in transportation.

The best means of caring for collections is often a matter of personal preference. Entomologists usually cut a small piece of thin, clear celluloid or a piece of fairly stiff paper about the shape of the upper part of an exclamation point (\blacktriangle), put the pin which is to fasten the specimen in the box through the heavier end and attach the insect to the point either by a good glue or, what is preferable, a little shellac dissolved in alcohol, or rubber cement. Only the smallest amount of adhesive substance must be used, and this is put on the point of the paper and the insect laid on it with a fine pair of forceps. It may be placed on its side, attaching by the pleura, just cephalad of the wing, or by the ventral aspect, but the former is preferable where only one specimen of a kind is kept; when there are several specimens, they may be attached at different points so as to give different views of the insect. The point of the pin is then stuck into the bottom of a box previously prepared, the top of which must fit tightly; a piece of camphor, fastened securely in the box, will help protect the specimens from the depredations of smaller insects. Regular boxes made for this purpose are easily purchased.

Where the specimens are to be subjected to repeated moves, as in the Army, this method has the disadvantage that the loosening of one pin may easily destroy many specimens during the transportation, and it has been found that there is less loss from breakage if the insects are put in small glass tubes, such as very small and short test tubes. In that case the tube should be carefully cleaned and a little dry absorbent cotton pushed firmly to the bottom of the tube. The insect is then introduced, care being taken not to break off the legs and other appendages. Two or three or even more insects may be put in the same tube, the number depending on the size of the mosquito, how it is spread, how carefully it is desired to display it, and how rare and valuable the specimens are. After the insect is placed in the tube, a piece of absorbent cotton is fitted like a cork and carefully pushed in till it just touches the mosquito sufficiently to steady it. The tube is then labeled, with name, place, and date of collection, and where possible, name of collector. The tube may also be corked and the cork paraffined, but for usual purposes this is not necessary. The chief objection to this method is that a fine mist of moisture, apparently the moisture of condensation, sometimes gathers on the inside of the tube, especially if not paraffined, and injures the specimen, but this can be partly avoided by a little watchfulness and by

keeping the tubes in a box so they are not subjected to continual changes of temperature. I have myself used it for about 11 years and found it a very satisfactory method of caring for specimens.

A variation on this method was suggested by Maj. W. J. L. Lyster, Medical Corps, United States Army, who fits the tube with a cork into which the eye of a needle has been pushed, and transfixes the insect on the point; or probably better still, uses the small piece of paper referred to above, as the entomologists do, bending it so as to carry the insect safely into the tube.

(b) Collecting for dissection may be made as already given, but if the killer be used the insects must be used at once, as it is necessary to have freshly killed specimens for this work. The insect may also be taken by inverting clean test tubes slowly over them, care being taken that the shadow of the tube does not fall on the insect, as that will probably frighten it and drive it away.

Traps as a means of taking mosquitoes are rarely considered, but there seems no reason why they should not be effectively used whenever specimens of mosquitoes are desired, and ought to be easily constructed in connection with windows in lighted rooms, the inmates furnishing the desired attraction; in tents or in the open where a small light (at night) and perhaps some pabulum as moistened sugar, honey, dates, etc., might be effectively arranged. For the day collection Stephens suggests "traps" made of roomy biscuit tins lined with felt, and says the mosquitoes retreat into these as the sun rises.

(c) In collection for experimental work in the transmission of disease, larvæ may be taken with a white enameled or "agate" tablespoon and put in glass tanks containing algæ and organic débris such as is found in the water from which they are taken, and some arrangement made to areate the water so it does not become foul. In some species the food of the larvæ must be carefully considered as they require and will thrive on only their own food, and Darling found that the aereation could be managed by "attaching a thick glass rod, having a fine capillary central canal, to the double bulb of the Pacquelin cautery apparatus, and the breeding-out jars areated for a minute or two morning and evening." Dr. Darling found in his experiment that the temperature needed to be between 72° and 84°. The pupæ were taken out morning and evening and placed in tubes half filled with water and plugged with cotton, and the newly emerged mosquitoes were transferred each morning to "biting jars." For these jars Dr. Darling found most useful lantern chimneys, provided with a ring platform of stiff paper at one end of the jar, as a resting place for the mosquitoes, and both ends of the chimney covered with "crinoline gauze," fastened by adhesive plaster and a strong rubber band. These jars were placed over small dishes with a little water

in a petrie dish cover and small pieces of dates or raisins as food. The results showed that those anopheles which had a preliminary feeding of blood before being fed with dates or raisins did better, and that the use of banana as a food for them seemed associated with bacterial and yeast infection of the mid-gut and apparently either destroyed the flagella of the gametes or in some other way prevented the development of the zygotes. It was also found that the mosquitoes fed on dates or raisins made better dissections than those fed on bananas.¹ The jars must be kept, both before and after biting, in a rather dimly lighted place and protected from the depredations of ants by kerosene cups.

If the adult free-living mosquitoes are desired it is evident they must be taken either with a clean tube or a trap, but of course there is always a question, if these specimens be used for experimental work, as to whether they were infected before or after their capture.

¹ Darling S. T. Studies in relation to malaria, 2d edition.

DISSECTION FOR MALARIAL PARASITE.¹

Only freshly killed mosquitoes are suitable for dissection. They may be taken in any of the ways suggested above, but perhaps the easiest is to find infected mosquitoes, invert a clean test tube over the insect, taking a number of tubes and using a tube for each mosquito. This enables one to kill the insects when desired, feeding the remainder on a little sugar and water or other suitable food. Some mosquitoes should be killed and dropped in a pill box on a little absorbent cotton, lightly covered with another wisp, a drop of 40 per cent formalin placed on the top of the box, care being taken not

to wet the insect, the box put in a firm mailing box and shipped, *at once*, for identification.

For dissection the mosquito is most easily killed by rapping the tube, with the mosquito at the end, smartly against the knee. (N. B.—This must *never* be done if the mosquitoes are required for identification, as most of the scales are knocked off by the jar.)

Put the mosquito on a slide, and while holding one wing pull off with a needle or forceps the legs and remaining wing. Take care not to pull off the proboscis by mistake.

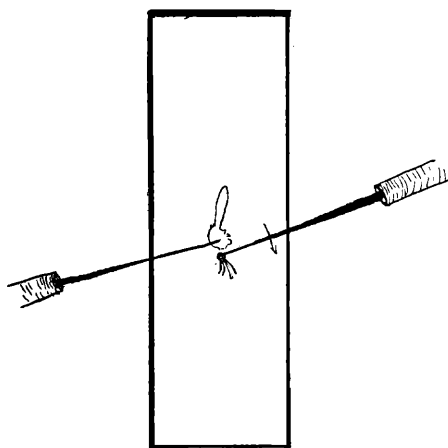


FIG. 26. After Stephens. Diagram to illustrate method of extracting the salivary glands of a mosquito.

Dissection of salivary glands.—(a) Put the trimmed mosquito into a drop of salt solution (1 per cent roughly) on a slide so that it lies on its *right* side with its proboscis *toward* you. (Fig. 26.) Do not *flood* the slide with salt solution, as the glands when extracted may float away and be lost. Remember that the glands lie just at the point of origin of the first pair of legs.

(b) Place the slide upon a piece of *white paper*, as you are dissecting a dark object. A dissecting microscope with a piece of white paper slipped over the mirror renders the object more easily seen and facilitates the dissection. Take a needle (in a holder if convenient) in each hand, holding them nearly horizontal. Place the *left* needle *on the*

¹ The directions for the dissection and staining, and the suggestions following, are taken bodily with almost no changes from Dr. J. W. W. Stephens's "Methods for detecting sporozoites and zygotes in mosquitoes infected with malaria." Bull. Ento. Res., Vol. II, pp. 1-84.

thorax so as to steady it and the right needle at the back of the head, and make a series of gentle, slow, "coaxing" pulls on the head with the right needle, taking about one-fourth to one-half a minute over it.

(c) If this has been done carefully (and anyone with the least delicacy of touch can succeed 99 times out of 100), a bit of white tissue is now seen attached to the head. This contains the glands.

(d) Examine under a one-half inch lens, remembering nearly to close the diaphragm as an unstained object is being examined.

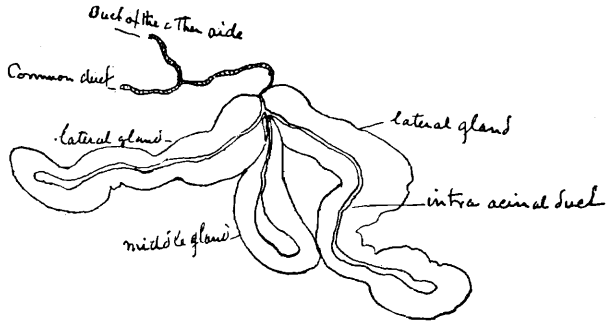


FIG. 27. After Stephens. The salivary glands of one side.

The glands are glistening fingerlike and a little twisted, and project from the end of the head, or possibly only their tips may be seen in the midst of some gray muscle or "fat body."

(e) *Separation from head.*—Put the left needle on the head and with the right cut or tear off the white tissue containing the glands. (N. B.—Take care that by this time the salt solution has not dried or that the glands have not stuck to the needle.)

Examination of the glands.—(a) The glands are generally quite free when dissected in this way, but even if still attached to a bit of tissue

it is quite unnecessary to separate them any further. It is not necessary that all six lobes should be present; three may be considered sufficient.

(b) If the salt solution has become turbid carefully draw the glands into a fresh drop of solution on the slide, remembering that the apparent right and left

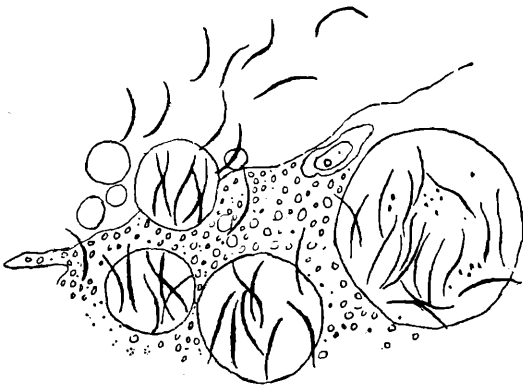


FIG. 28. After Stephens. Sporozoites in salivary gland.

under the microscope are actual left and right on the slide.

(c) Drop a cover glass over them.

(d) Examine with a one-sixth or one-seventh inch lens. An oil immersion is unnecessary for detection of sporozoites, as they are in length about twice the diameter of a red cell.

(e) *Sporozoites* are seen in such a fresh preparation in hundreds as thin, rather glistening curved rods. The diaphragm should be properly adjusted.

Staining of sporozoites.—(a) Smear off the cover glass.

(b) Dry as rapidly as possible (over flame).

(c) Fix in alcohol for a few minutes; 5 is ample.

(d) Stain in Romanowsky or Leishman, etc., 10 minutes or longer.

Compare carefully sporozoites from quartan, simple, and malignant tertian cases. Also examine if there be any evidence of male, female, and indifferent sporozoites.

Dissection of the mid-gut (stomach).—(N. B.—Keep the mosquito, if caught in huts, for two to three days till the blood is all digested, as it is otherwise almost impossible to see zygotes.)

(a) Place the mosquito (either a fresh one or the one from which the glands have been extracted) *on its back* in a drop of clean salt solution. With a needle nick or tear the chitinous body wall on each side as near the “tail” as possible. Place the *left* needle on the thorax, and with the *right* needle on the extreme tip make a gentle traction as before.

(b) If carefully done, all the viscera will be pulled out, viz, esophagus and diverticula, mid-gut, Malpighian tubes (5), hind-gut, ovaries (2), etc. When the tension is relieved the mid-gut assumes a flask-shaped saccular appearance.

(c) Cut the mid-gut off just below the Malpighian tubes. Also cut through the upper end of the esophagus, to which may be attached the diverticula, recognizable by the gas bubbles (CO_2) they contain.

(d) Remove everything from the slide except the mid-gut (stomach). Add a clean drop of salt solution. Drop on a cover glass and press gently, so as to flatten out the stomach. Examine with a one-sixth inch lens, taking care to adjust the diaphragm properly.

(e) If the normal structures of the stomach are known, there is no difficulty in recognizing zygotes (zygotes if scanty, 1 or 2 will be found at the bottom end of the stomach nearest the Malpighian tubes).

(1) The younger forms are clear oval or round bodies $6-7\mu$, i. e., about the size of a red corpuscle, containing *definitely seen pigment granules*.

(2) The larger forms have a *distinct cyst wall* (oocysts) and still retain pigment which is unmistakable.

(3) The largest oocysts have lost their pigment and are clearly defined cysts ($40-60\mu$) filled with hundreds of sickle-shaped bodies (sporozoites), which escape on rupture.

(f) “*Black spores*” (Ross).—Although very many dissections of anopheles were made by Christophers and myself in Africa, these brownish or black sausagelike bodies, which sometimes are found in

the large oocysts, were never seen by us. In India we saw them only twice in hundreds of dissections, and on both occasions they were in the region of the salivary gland. They are, however, far commoner in the oocysts of *Culicines* fed on *Proteosoma*. According to some authors they are parasitic sporozoa, but nothing is known as to their life history.

Staining of zygotes.—(a) Draw some 10 per cent formalin solution under the cover glass by means of blotting paper, and float off the

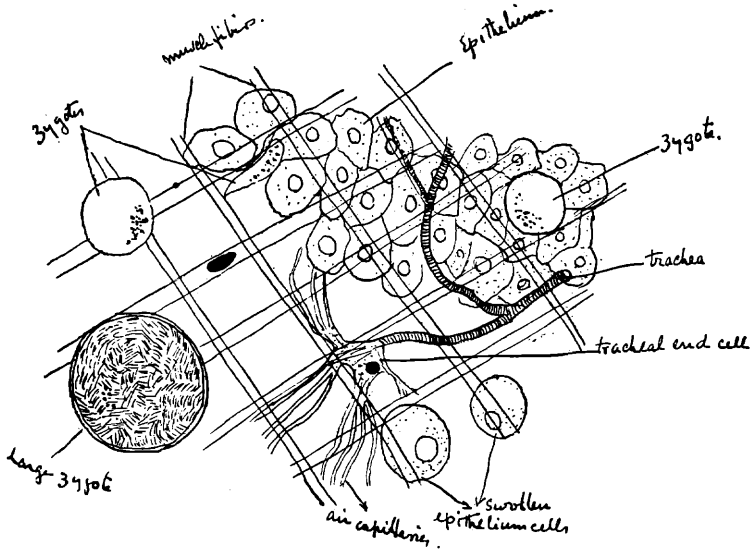


FIG. 29. After Stephens. Microscopic appearance of mid gut showing cell structure and zygotes.

cover glass carefully; the stomach will probably remain attached to it.

(b) Wash in water.

(c) Stain lightly with methylene blue.

(d) Wash in water, dehydrate, clear in xylol.

(e) Mount in balsam.

Good preparations are easily obtained in this way.

Parasites that may be met with during dissection.—1. Trematodes, encysted in the thorax, also free in the stomach.

2. Nematodes, in the thorax or abdominal cavity.

3. Sporozoa: (a) masses of sausage-shaped bodies about the salivary glands; (b) sporocysts containing 8 spores; these occur in large numbers, replacing the yolk of the eggs (Fig. 30); (c) gregarines, free in the stomach or encysted in the malpighian tubes.

4. Flagellata, in large numbers in the gut. They are *Crithidia* forms.

5. Microorganisms and *Nosema* (?) in the diverticula.

6. Ecto parasites: The reddish larval stages of water-mites (Hydrachnidæ) are common. The adult stages of these are unknown.

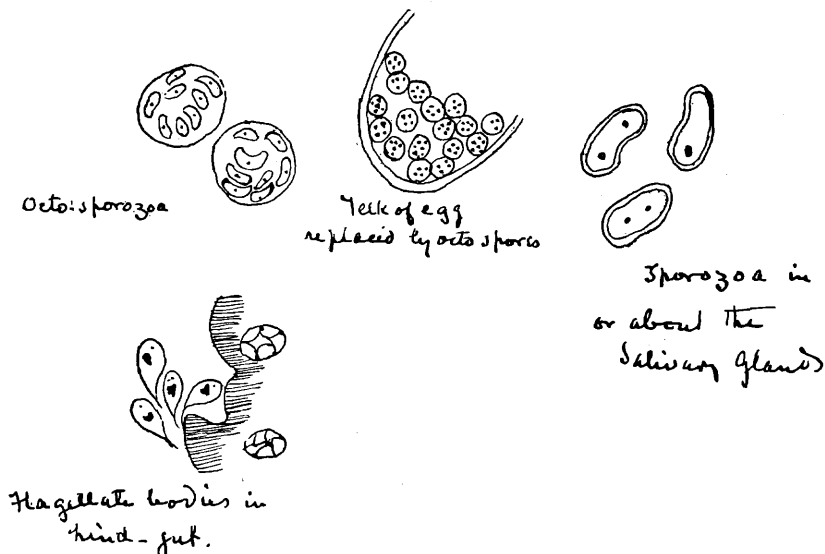


FIG. 30. After Stephens. Protozoa other than the malarial parasite found in anophelines.

INFECTION OF ANOPHELINES.

Our information on this subject is deplorably inadequate. A systematic examination of suspected species at all seasons of the year would certainly yield results of considerable practical value. Nor should the Culicines be neglected in this respect. An investigation of the commoner house-frequenting species might yield important information.

PROBLEMS CONCERNING THE INFECTION OF MOSQUITOES WHICH NEED FURTHER INVESTIGATION.

I. Bodies of uncertain significance found in the salivary glands of various mosquitoes.

(a) In a large anopheline (*Myzorhynchus* (?) Sp.), a species not frequenting houses, caught in the bush in Sierra Leone at a considerable distance from human habitations, sporozoites were found in one of four examined. The nature of these is unknown, and further observations are much needed.

(b) The examination of specimens of an undetermined species of *Culex* at Mabang, Sierra Leone, showed that 10 per cent contained bodies resembling sporozoites, but more slender twisted and irregular in outline. Some of those Culicines had fed on human blood; others were caught in the bush. Here again we have no knowledge as to the nature of these bodies.

(c) In another undetermined *Culex*, 5 to 10 per cent of the specimens contained straight bodies in the globules of salivary secretion. These resembled sporozoits, but were probably crystalline in nature.

II. Alleged transmission of malarial infection through the eggs of the mosquito.

Statements have been made, without a vestige of proof, that such transmission occurs. It may be well, therefore, to examine the egg, of anophelines for sporozoits. Even should infected eggs be found, it would not be clear how they could transmit infection to the adult mosquito hatched from them, as there is no evidence that sporozoits multiply or undergo further development in the mosquito. If we suppose that hereditary transmission does occur, the form of the parasite may be quite different from anything we know. Hence the study of the contents of normal eggs is of importance.

III. What are the conditions which determine successful infection of anophelines fed on malarial blood?

In feeding experiments only a certain percentage are as a rule successful. In experiments made by Christophers and Stephens in India we got no result until we kept the anophelines in a hot incubator, though in the villages they were naturally infected. Is it quite certain that no *Culicines* can transmit malaria?

IV. How many persons can one anopheline infect?

We have no data on this point. In the case of *Culicines* the brothers Sargent have shown that an infected *Culicine* can infect two but not three consecutive birds with *Proteosoma*. Similar experiments might be made in the case of anophelines and man, but in case this is not possible the experiments should be made with *Culicine* sporozoits on birds; and, indeed, if opportunity offers, bird malaria still affords a fruitful field of research. In the greater part of Africa, however, *Proteosoma* does not exist, but in the mode of transmission of *Halteridium*, hæmogregarines, etc., there is abundance of work to be done.

V. Does the percentage of infected anophelines vary from month to month, and if so, to what extent?

VI. How long does an anopheline once infected remain so?

VII. Penetration of red cells by sporozoits.

Using a mixture of finger blood and sporozoits from the salivary gland, Stephens and Christophers were unable to observe penetration of the red cell by the sporozoits, but the latter appeared to change into rings. Nor did Schaudinn, making the same experiment, succeed, but on using sporozoits taken from a large oocyst in the stomach he was successful. These experiments are worthy of repetition and an explanation should be sought for the difference in the behavior of the sporozoits from the two sources if the facts are correct.

VIII. Properties of the salivary secretion.

As far as I am aware, nobody has yet repeated Schaudinn's observations. He states that the salivary gland rubbed into an abrasion does not produce the irritation of a mosquito bite, but that on the contrary if the esophageal diverticula be rubbed in, the well-known itching effects are experienced, which he attributes to the enzymes produced by low bacterial forms in the diverticula. Any fact established about mosquitoes is of value, for we never know to what practical purpose such knowledge may not be turned.

To these might be added the question as to personal immunity to mosquito bites. Are some people immune to the bites of or so repellent to mosquitoes that they are not bitten or the "bite" produces absolutely no effect? If so, what are the qualities which go to produce this immunity?

THE MOSQUITO PROBLEM.

A SUMMARY.

Where mosquito-borne diseases exist two phases of the mosquito problem are met: (1) What disease-bearing mosquitoes are present? This divides itself into (a) what anophelines are present, and (b) are *Stegomyia fasciata*, *Culex fatigans*, or *Mansonia uniformis* and *africana* present?

To decide these questions careful collections of adults, taken with reference to the supposed habits of the species, must be made, remembering that to obtain reliable results real effort, care, ingenuity, and patience are necessary in making these collections.

Anophelines are often shy, but they may be found in houses, case-mates, stables; in culverts, etc.

Stephens¹ says, in suggesting where to find infected anophelines in the Tropics:

“(a) Select a village or any small collection of native huts where you know, either from a blood examination or from spleen palpation, that the children are infected with malaria.

“(b) Anophelines and also Culicines will be found *in the huts*, near the fireplace, behind curtains, in cupboards, behind clothing, in old boots, collections of bottles, lumber, rubbish of all sorts, on the thatch hanging to the sooty straw and cobwebs where sometimes they must be stirred up, as they often lie deeply hidden, and on the outside of mosquito nets before the sun is well up; *in out-houses, cow houses, piles of dried grass in barns.*

“(c) In short drains or under bridges they may sometimes be caught in hundreds.

“(d) Or finally ‘traps’ may be set. These are made of roomy biscuit tins (lined with felt) with the lid ajar, the mosquitoes retreating into these as the sun rises.”

In the Philippine Islands it is often easy to take anophelines just before sunrise, as they begin to move preparatory to leaving the house. I have often taken 40 in a few minutes at this time by inverting a large test tube over them as they fluttered, hunting the way to the windows.

Stegomyia fasciata may be comparatively easily taken if present in any number; it bites and flies most readily in the daytime, but

¹ Stephens, J. W. W. Methods for Detecting Sporozoites and Zygotes in Mosquitoes Infected with Malaria. Bull. Ento. Res., Vol. II, pp. 1-84.

can often be taken in large numbers (in the Philippine Islands at least), about 2 or 3 p. m., resting on the walls, bed nets, etc., in moderately darkened rooms.

Culex fatigans may be taken resting, or sometimes flying lazily during the daytime in houses, especially in partly darkened rooms, or when actively feeding at night, or gorged specimens can easily be obtained in the early morning on or in the bed nets, and in poorly lighted rooms even well after sunup.

Mansonia, both species, are fierce biters, and on account of their voracity are comparatively easily taken when feeding at night. *M. uniformis* is reported a carrier of *filaria* in Africa, but unfortunately the two species (*uniformis* and *africana*) are much alike and seem to have been confused so that it is possible that either or both of the species are connected with the transmission of this disease.

As indicated above, they may be taken by inverting a *dry* test tube *slowly* over the insect; some should be killed at once, dropped onto a little absorbent cotton in a pill box, placing a thin layer of the cotton over them to steady them; add a drop of disinfectant so it does not touch the mosquito; label the box *when* and *where* caught, and *name of sender*; put in mailing box and ship at once for identification.

(2) How shall these species be controlled?

It has been shown by the work in the prevention of malaria, both in the Orient and on our own continent and adjacent islands, that while much relief can be obtained by the wholesale destruction of adults, and in fighting yellow fever that this is a necessity, still the permanent and most valuable results come from the destruction of breeding places. Comparatively lately also it has been shown that it is not necessary, so far as the control of disease is concerned, to destroy the breeding places of all kinds of mosquitoes, and that such an undertaking may add very greatly to the expense of the control without adding materially to the health of the population.

Where are the breeding places?

As already indicated these depend largely on the species present, although some forms are so indifferent as to the quality of the water and location as to indicate a double line of investigations needful. If the species present and breeding places are unknown, then too much stress can not be laid on the necessity of never passing by any sort of water, large or small, hidden or open, fresh, salt, or filthy, stagnant or swiftly running, until you have found the breeding places of the species you wish to control. To prejudge the place in which any species whose life habits have not been studied may breed is to invite failure, while to find them and the method of control fitted may tax severely the patience, continuous effort, and watchful observation of the investigator.

Even when the species and breeding places are known, it may easily require much patience and effort to find them, but until that is done no control of the mosquitoes in their constantly recurring broods is possible.

How shall these breeding places be treated?

The question is a broad one, and its answer as varied as the conditions, for manifestly no one method is suited to all conditions, and each locality presents some peculiarities of its own.

Ditching, open or underground, in tiled or piped drains, is probably one of the most efficacious means, and even here the rate of current and the period of recurrence of flushing must be considered.

Filling is desirable at times, possibly cheaper than ditching, but often not so satisfactory.

Cleaning, and *keeping clean* the existing ditches, water courses, ponds, etc., i. e., removing grass and weeds from the edges, as well as any débris that hinders the free movement of the water controls some species.

The destruction of small receptacles, piercing of bamboo, etc., the inspection and repair of house gutters.

The introduction of certain fish, such as "millions" into ponds and open basins of water.

Larvæcides of various sorts, which, however, can not be used where they destroy the fish of the country or injure the drinking water.

In the Federated Malay States and in British Guiana, so Dr. Watson writes me, some species disappear when the ground is cultivated, but this depends on the opening up of a country.

The destruction of larvæ food brings up the question of what larvæ eat, and this varies with the species under observation from algæ, small crustaceans, and fragments of larger insects, to excrementitious material from large animals, etc.

Each land, each locality, each species presents its own problem, and until more is definitely known of the habits of the individual species, each demands a solution from the worker in his own field. In this connection Dr. Darling writes me: "*Each region and each locality must be studied by itself, even though the region contain anopheles, the bionomics of which for other regions are well known.*" This is one of the most important things in antimalarial work."

Unfortunately to these parts of the problem must also frequently be added the question of expense, and how best to use the means at the disposal of the investigator, so that it becomes a question in economics as well as bionomics, and this phase may also call for much thought and ingenuity.

The following very suggestive points are made by Dr. Stephens:¹

Stephens, J. W. W. Bull. Ento. Research, Vol. II, pp. 1-84.

SUGGESTED LINES OF RESEARCH IN THE LIFE HISTORY OF ADULT MOSQUITOES.

"There are numerous points concerning adult mosquitoes on which further light is required, problems which are to be solved rather in the field than in the laboratory. Such, for example, are:

"1. Length of life.

"2. Distance of flight. It might be possible to mark mosquitoes, e. g., with a stain or powder, and to trap them again.¹

"3. Habits, especially of the male, and conditions of fertilization.

"4. Effect of jungle, bush, bamboo thickets, and banana-clumps as screens. Is it advisable to clear all jungle indiscriminately, without regard to its screening function?

"5. What are the natural enemies of adult anophelines?

"6. Is it possible to discover any plant or substance that will entirely repel mosquitoes, or, on the contrary, that will irresistibly attract them?

"7. What is the best form of mosquito trap and to what extent can mosquitoes be diminished by persistent trapping every night in native huts or European bungalows?

"8. Habits in the dry season?

"9. When does egg laying of anophelines take place in nature? Has it any relationship to food? What determines selection of any particular water?

"10. How often does an anopheline leave a native hut or bungalow?"

(This is possibly another chance to try staining.—C. S. L.)

¹ This was effectively done by the department of sanitation under Col. Gorgas, Isthmian Canal Commission Report, Jan., 1913, p. 46.

In preparing this paper I have made free and extensive use of all the available authorities, and am especially indebted to the following authors:

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C. S. LUDLOW.

WASHINGTON, D. C., *November, 1913.*

